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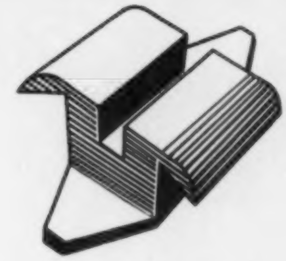

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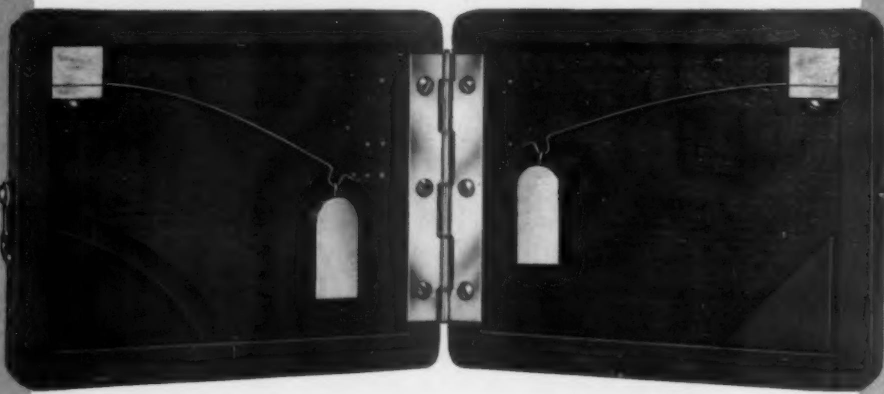

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American Journal
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Vol. 39 October, 1953 No. 10

Original Articles

CEPHALOMETRICS FOR YOU AND ME

Cecil C. Steiner, D.D.S., Beverly Hills, Calif.

It is significant, and I believe proper, that the majority of the orthodontic articles published recently have referred directly to, or indirectly have made use of, information gained from the use of cephalometers. Of this we can be sure: The cephalometer is here to stay, and those of you who are not using cephalometrics in your everyday clinical practices now must soon bow to its importance, accept the added burden it imposes, and master its mysteries if you are to discharge your full obligation to your patients.

It is my belief that much of the confusion among clinical orthodontists regarding cephalometrics stems from the fact that most of the literature regarding it has been written by and for teachers and research workers. It is my intention to write this article in the only language I know, "shop talk," with the hope that it therefore may be better understood by others like myself who deal directly with patients.

The cephalometer obviously is one of the most important of all of the contributions made so far to the study of growth and development and to the science of orthodontics in general. It is the very foundation on which present-day thinking and knowledge in orthodontics are based. Much credit must go to Dr. Holly B. Broadbent for the development of the cephalometer and to Drs. Brodie, Downs, Wylie, Thompson, Margolis, Higley, Adams, Reidel, Graber, and others for the development of the technique of its use and for systems of assessment that have made it useful.

It is apparent that the cephalometer has not been promptly accepted, nor generally used by clinical orthodontists. It has been claimed by many that it is a tool of the research laboratory and that the difficulties and expense of its use in clinical practice are not justified. Many have argued that the information

Read at the Sextas Journadas Ortodoncicas, Buenos Aires, Argentina, November, 1952, and at the meeting of the Edward H. Angle Society of Orthodoncia, Victoria, Canada, May, 1953.

gained from cephalometric films, when used with present methods of assessing them, does not contribute sufficient information to change, or influence, their plans of treatment. Much of their discouragement stems from the mistaken statements of some who, in writing of the cephalometer, have claimed accuracies that do not exist or assumed direct benefits that were not easy to discern. No one should expect to get satisfaction or benefit from the use of the cephalometer until he has firmly in mind the fact that findings from cephalometric x-ray pictures are, for the most part, merely circumstantial evidence which must be accepted as such and coordinated with other evidence before it becomes useful.

In the past I, too, had misgivings as to the practicability of cephalometrics for the clinical orthodontist, but, having been through all of these phases of doubt, apprehension, and experimentation, I now can say that, even though I cannot read from cephalometric pictures direct answers to all of my problems, I do not feel adequate in analyzing a case as to what its treatment should be and, of equal importance, what it has been unless I have cephalometric records before me. They are used with all cases in our practice and we regard them as being much more important for diagnostic purposes than models.

Experience in analyzing cephalometric x-ray pictures of patients being treated in our office, and particularly in attempting to convey the information that we find in them to parents, has developed in my mind some opinions regarding methods of analysis for the use of clinical orthodontists that I feel and hope may be useful to others. Much of this assessment method is made up of ideas of others. The most important of these comes from Drs. Downs, Wylie, Reidel, Thompson, Margolis, and others. I have taken ideas from these men and their ideas have engendered within me other ideas which we think are more direct and more useful for our purpose. I make no claim that they should replace other methods, but I do believe that for the purpose of the clinical orthodontist, they are direct and useful. We know that they are more easily understood by parents with whom we discuss them.

Anyone working with cephalometrics soon learns that hundreds of measurements and combinations of measurements can be made from cephalometric x-rays. Many of these have value. For each of us the problem is to determine what we want from an x-ray picture for our use, in our practice. In our office, the following measurements and assessments are made. I now shall attempt to justify them.

Our cephalometric x-ray pictures are taken in a cephalometer of standard design, and with an x-ray machine of much more than average power and quality. Our pictures are taken by a man who is a specialist in roentgenography and who has had special training in this special field. The pictures we use are therefore at least of average quality, or above it.

Very early in our experience with cephalometrics we encountered the difficulties of accurately locating certain important anatomic structures. Outstanding among these is that of distinguishing between identical structures on the right and left sides of the head. The literature on the subject would indicate that all that is thought to be necessary in such a case is to take cognizance of

the diverging rays from the target of the tube, and to remember the fact that the side of the head closest to the tube is magnified less than the side farther away from the tube. It is assumed that the structures upon the side nearest to the tube will be shown on the film closest to the point where the central rays strike the film. This method is often used to identify teeth as to whether they are of the right side or the left side. It seems to me that such a determination is largely guesswork, for, as we all know, positions of teeth in opposite sides of the same jaw are rarely entirely uniform. That is true also of the teeth of the same side of opposing jaws. Then, too, for lack of positive knowledge, it is taken for granted that the right and the left ear holes occupy symmetrically opposite positions in the head and that the superposition of the right and left porion points will supply a true profile picture. In our experience this is not true. Very obviously, such structures as the porion points on the bony auricular canals, and in many cases the infraorbital points, are difficult to locate accurately. It is also difficult to determine the right one from the left one. We must recognize also that as the head is rotated, all structures not located in the median plane of the head change positions rapidly, the structures of the opposite sides of the head moving in opposite directions to each other.

Fig. 1.—Demonstration of movement of the patient's head on the ear posts during the taking of cephalometric x-ray pictures.

Our literature gives evidence of the struggles among our research workers to find anatomic points, or lines, for superposition from which to determine differences and changes between moving parts, and we note with interest that nearly all of these seek points and lines located in the median plane of the head for this purpose.

Working with cephalometrics discloses the difficulty of accurately locating the porion points. This difficulty can be explained on the basis of the fact that porion is a point upon the external exit of the bony auditory canal. This point is covered by soft tissue intervening between the ear posts and this porion point. Tracings are not made from the porion point itself, but from the top of the ear posts which approximates it in position. As proof that patients can and do move in relationship to the ear posts when pictures are taken under the circumstances that I have mentioned, we offer the following evidence.

The tracings of the first two cases (Fig. 1, *A* and *B*) typical of many in our files, are of patients of whom several cephalometric x-ray films of each had been

made within a matter of minutes of each other. These films were routine pictures taken for our office, one being the regular cephalometric profile x-ray picture with the teeth in occlusion, and the other being the same except with the mandible in rest position. In these instances, the patient was not removed from the head holder, nor were the adjustments changed. The usual precaution of having the ear posts properly inserted in the ears and some of the patient's weight settled evenly on the ear posts were observed. By superimposing the pictures on cranial landmarks located in the median plane of the head of the patient, porion points were seen to move in relationship to each other as shown. As a result of this movement the Frankfort plane varied as seen in Fig. 1.

I, who know more of the technique of having x-ray pictures taken than does the average orthodontic patient, was placed in the caphalometer six times over a period of six months. I am sure that I have passed my growth period. These pictures (Fig. 1, *C*) were not taken to test the accuracy of locating the porion points, but instead to determine whether or not, as evidenced by cephalometric x-rays, the rest position of my mandible would remain constant throughout the period. When these films were superimposed on the cranial outline, and also on some distinctive and easy to recognize fillings in my maxillary teeth, a picture of the ear posts for five of the films varied as shown in Fig. 1, *C*.

It is understandable that the Frankfort plane would be chosen as a base line for cephalometric appraisal. It was a logical choice because it conformed to the traditional methods established by anthropologists. It seems probable that anthropologists used it originally because the porion points and the infraorbital points were visible and therefore were available to them from the outside of a dry skull. Points S and N would not have been available to them without opening the skull, or using an x-ray picture of it. In orthodontics we are not dealing with dry skulls and the porion points and the orbitali, not being directly visible to us, are not accurate for our use. Points S and N are clearly visible in the x-ray pictures and can be located easily and accurately. It is of special importance to note that these points are located in the midsagittal plane of the head and, therefore, that they are moved a minimum amount whenever the head deviates from the true profile position.

A true profile picture, however, is unfortunately rarely attained, for accuracy with our present methods of mounting heads in cephalometers must as yet be a matter of degree, varying because of reasons already mentioned and also varying in proportion to the difference of location of right and left auricular canals to the sagittal plane, and to each other. True accuracy also varies to the degree that the patient has moved his head from an even mounting on the ear posts of the cephalometer.

Because the points S and N are both located in hard, nonyielding tissue, are directly and easily visible in a profile x-ray picture, and particularly because they are located in the midsagittal plane and therefore are displaced to a minimum degree by movement of the head, we have chosen the line SN as a reference line for all of the assessment measurements for which such a line is necessary. If it should be argued that this line is outside the face and therefore

is less useful as a line from which to judge facial proportions, I would answer that in this respect it has virtue and advantage because it is used only as a common reference line and is equally independent of facial structures. Things referring to the same thing have reference to each other.

Having determined a base line for our measurements, the question now arises as to what use we want to make of it. What do we want to learn, and what will we be required to explain to the parents of our patients regarding this knowledge?

One of the first questions is likely to be, "Does Willie have a good chin, and if not, what are you going to be able to do about it?" An equally important question may be, "What have you done about it?" A question in its simplest form will be, "Is Willie's chin forward or backward in relation to other structures of his head?" "Forward or backward to what structures?" The answer I want is, "Forward or backward to those structures that will effect his facial appearance and the impression he will make on the people about him."

To accomplish this, it seems to me that the method of Richard Reidel best serves our purpose, that method being the employment of the angles SNA and SNB (Fig. 2).

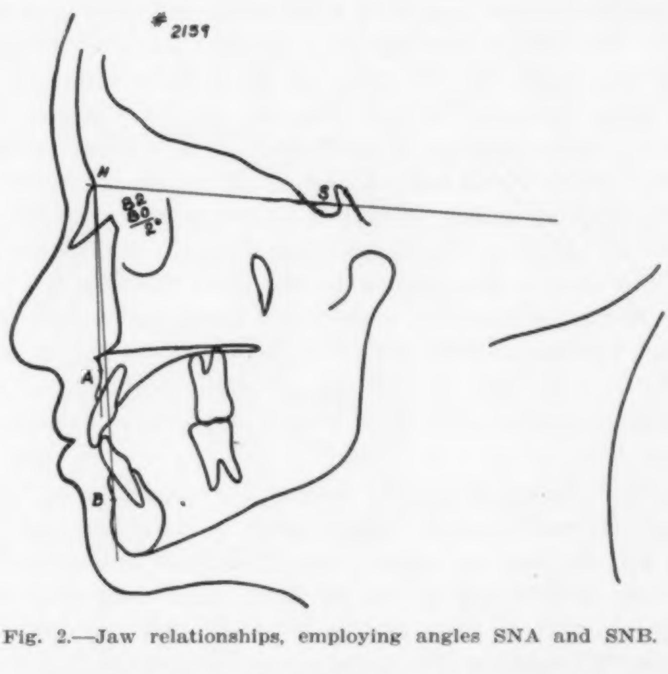


Fig. 2.—Jaw relationships, employing angles SNA and SNB.

To facilitate easy reading and to demonstrate our findings to others more easily, we use red for all lines having to do with the teeth of the maxillary arch, and green for those of the mandibular arch. For those relating to the mandible, brown is used. All other lines are in black.

I am interested in, but not greatly concerned about, the angle SNA because it merely shows whether the face protrudes or retrudes below the skull. I am greatly interested, however, in the difference of the angles SNA and SNB,

which in reality is the angle ANB, because the lines NA and NB are related to the same thing and the difference in their relationship gives a direct reading of the relationship of Willie's chin to other structures of his face. It is Willie's chin and not his sella turcica that interests his mother.

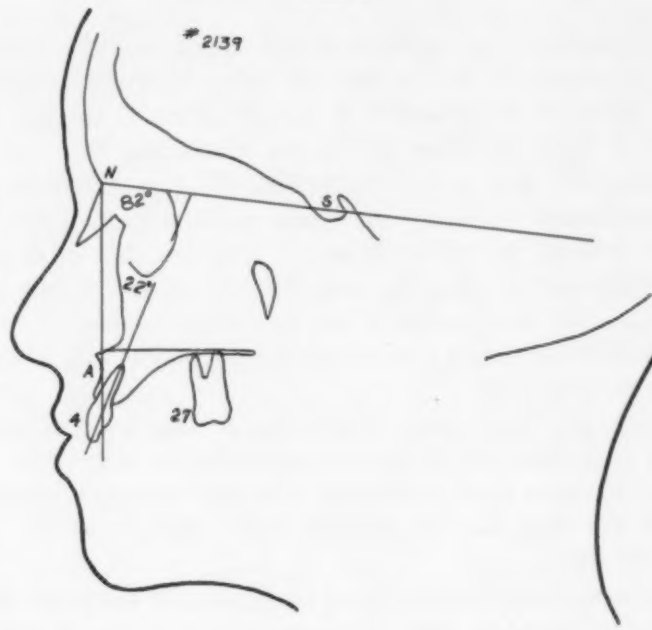
Our efforts have been to simplify tracings and to use methods that give direct readings in the areas to be judged. As an equivalent example, I might show to Willie's mother my fountain pen held in my left hand and a one-foot ruler held in my right hand. I might say, "Look, here is five inches indicated on this ruler in my right hand, and it looks to me as if that pen in my left hand is about five inches long," and I might convince her. A better method would be to lay the pen on the ruler and say, "Look, you can see by the ruler that this pen is five inches long." By this visual method I can show to her that a chin, which is on the average 2 degrees distal to the maxillary structures as evidenced by the angle ANB is in Willie's case perhaps 1, 2, 3 or 4 degrees mesial or distal to that of an average chin (Fig. 2).

Many attempts have been made in recent years to orient teeth, particularly the lower central incisors, to what has been referred to as "its relationship to basal bone," attention having been centered principally upon the central incisors. Its axial inclination has often been mentioned as related to the "mandibular plane." Our observation has been that the so-called mandibular plane as used has been a variable line, for there can be no such thing as a straight line parallel to the lower border of the mandible, for the lower border of the mandible is a curved line, not a straight one. There has been great variance in judgment of what the mean of this curved line is. It seems to me that the angulation of the lower central incisor to such a line is as much an appraisal of the length of the ramus as it is of the backward or forward inclination of this lower central incisor. Unless a conciliation of the rules relating the lower central incisor to the mandibular plane of a deformed mandible is made by some such method as Tweed has recently devised, it seems to us that this measurement has little value. We contend that the method we use to locate the upper and lower teeth in the denture is more direct and more important than those that have been used in the past.

By our method the upper central incisor (*1*) should lie on the line NA in such a way that the most mesially placed point of its crown is 4 mm. in front of the line NA and its axial inclination is at 22 degrees to the line NA (Fig. 3). We prefer the use of this line to that of facial plane because it is established by two fixed points, one of them on the maxillae and in juxtaposition to the tooth in question. In contrast, the facial plane is dependent upon a changeable moving part, the chin point pogonion. It will be noted that we orient this incisor to the line NA as to both location and angulation, both measurements being vital to us for diagnosis and for comparison to tracings made at a later date. In an attempt to relate all things to the same thing, and thus to each other, we began by recording the axial inclination of the upper central to the line SN, but from experience we found that, like all other measurements which are far removed from the points of their usefulness, this measurement has

little meaning to us or to others, and so we have ceased to use it. Much valuable information may be quickly obtained by observing where the line representing the axial inclination passes in relationship to the orbit. It normally intersects the orbit near its lowest point.

Fig. 3.



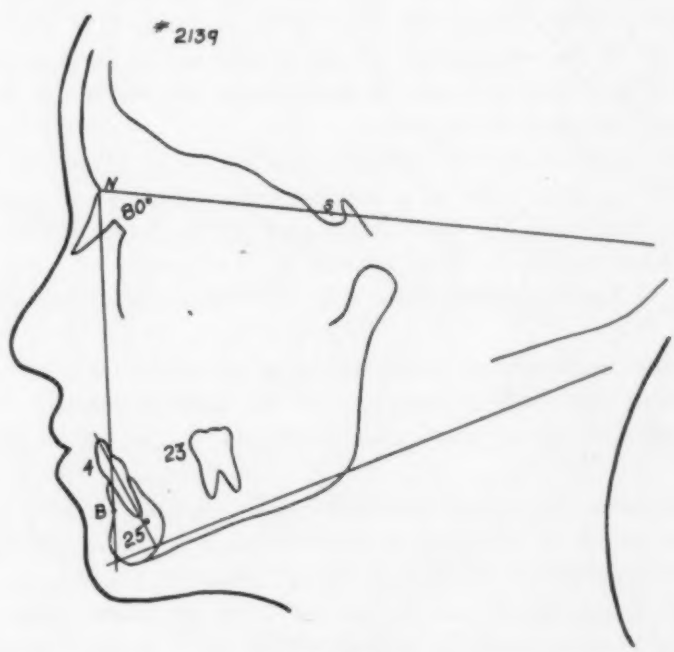


Fig. 4.

Fig. 3.—Orienting maxillary teeth.
Fig. 4.—Orienting mandibular teeth.

We also measure the upper molar ($\underline{6}$) to the line NA (Fig. 3) by measuring from the most mesial point on its crown to the line NA. A standard for this measurement is useless because of the number of teeth intervening and the variations in their size. This measurement is useful at a later date in determining whether or not the molar has moved forward or backward in relationship to this line.

By the same method that applied to the upper central incisor we relate the lower central incisor ($\overline{1}$) to the line NB (Fig. 4), our standard being that the most mesial point on the crown is 4 mm. in front of the line NB and the axial inclination of the tooth is at 25 degrees to the line NB. We also record the measurement, lower first molar ($\overline{6}$) to NB, for future reference. It seems to us quite as important to locate the lower incisors as to both location and angulation as is true of the upper incisors. The line NB is dependent upon a point (B) on the mandible close to the lower incisor, and serves an equivalent purpose to the line NA for the upper incisor. This method of orienting both anterior and posterior teeth to a line intimately associated with their basal bones is both effective and valuable.

We believe that the location and angulation of these teeth to these respective lines is of more importance to us for our appraisal of cases than were former measurements or systems that have been available, and it is certain that this visual method is not only easy to describe to the parents of our patients, but that it is very effective as well.

Because the measurement of the axial inclination of the lower central incisor to the mandibular plane is well established and often discussed, we continue to record it (Fig. 5), but we have come to value it principally as part of the assessment of the warpage of the lower part of the face, and we feel that its inclination to the face is largely determined by the degree of underdevelopment of the condylar growth centers.

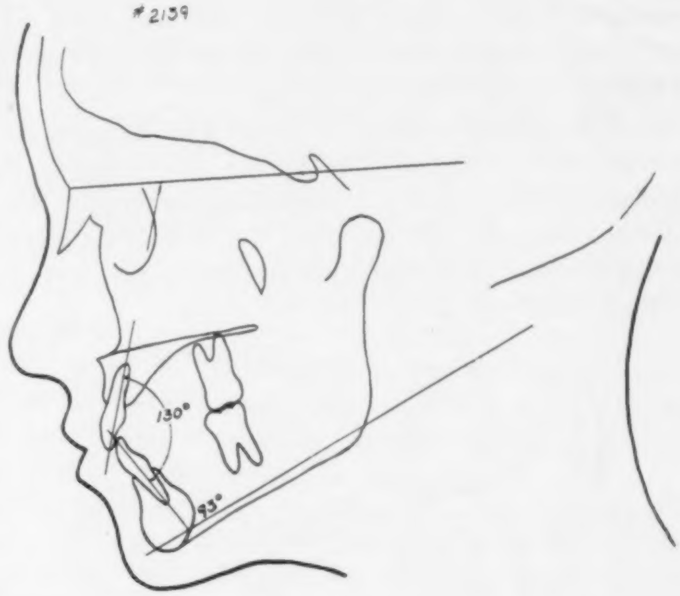
The angle upper inciser to lower incisor ($\underline{1}$ to $\overline{1}$) (Downs), as shown in Fig. 5, continues to have value as a supplementary method of appraisal of the angulations of these teeth to each other and to the face. This measurement indicates the total variation from normal of these teeth to each other. The angle of each to its respective lines NA and NB shows where the deviation lies.

A cephalometric survey of a case would be incomplete without an appraisal of the location of the teeth in occlusion to the face and skull. We therefore measure the angle of the occlusal plane to SN (principle of Downs) as shown in Fig. 6.

One of the most important determinations to be made from cephalometric tracings is the degree of warpage, or malformation of the mandible itself, and perhaps the surfaces with which it articulates. For this purpose the angle GoGn to SN (Fig. 6) is somewhat useful, but not fully adequate. Here lies a great opportunity for someone to devise still better methods of appraising maldevelopments in this important area. Drs. Wylie and Johnson deserve credit for the work they have done on it.

It will have been noticed that the line GoGn has been taken as representing the body of the mandible (Reidel). This has been done because of the confusion among orthodontists in the matter of determining what line represents the

Fig. 5.



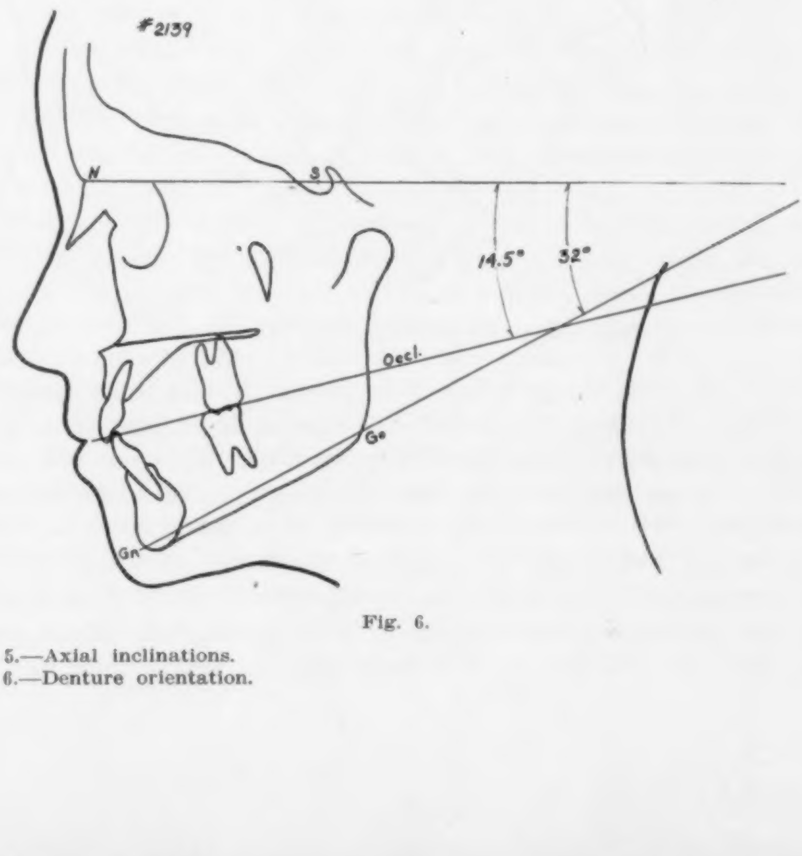


Fig. 6.

Fig. 5.—Axial inclinations.
Fig. 6.—Denture orientation.

lower border of the mandible, because such a line does not express what we desired of it. We prefer a line which more nearly represents the mass of the body of the mandible, rather than its lower border.

The location of the mandible and its relation to other structures are important to orthodontists. Equally or even more important is its function which is particularly expressed by its motion. We have borrowed from the ideas of Thompson, Brodie, Wylie, Reidel, Ricketts, and others in an attempt to show both location and motion by the following method.

In order to locate the mandible now, for comparison purposes at a future date, we borrow directly from the ideas of Wylie and erect a line from the most distal point of the head of the condyle perpendicularly to the line SN (Fig. 7). This intersection we call point E. SE expresses the mesiodistal location of the condyle. Observation of the changes that occur in this measurement during and after treatment has been interesting and often surprising.

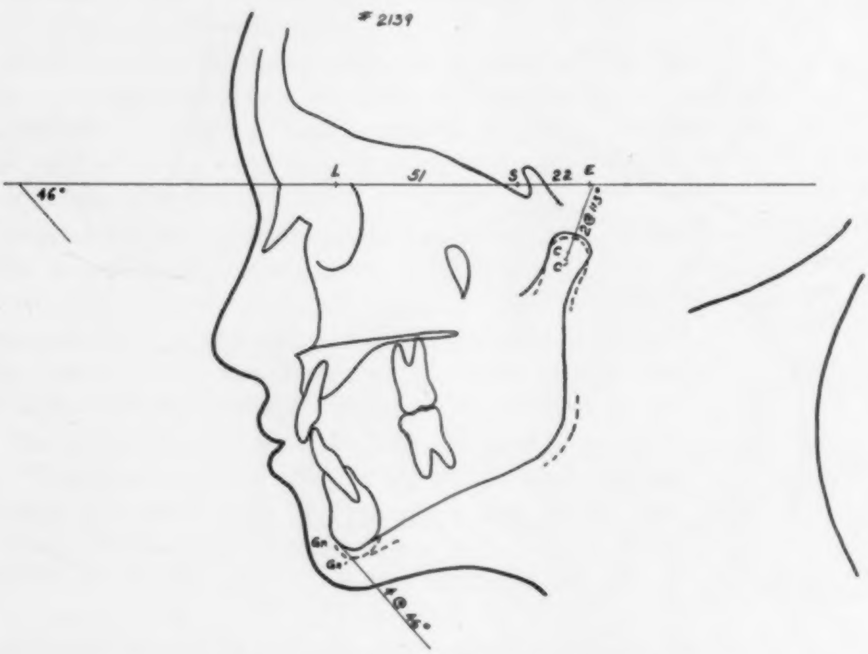


Fig. 7.—Location and motions of the mandible.

In order to locate the mandible more accurately and to assess its effective anteroposterior dimension, we project the most anterior point of the body of the mandible (pogonion) to the line SN (principle of Wylie) and call this point L (Fig. 7). The measurements SL and LE are also useful in assessing changes in position and effective size of the mandible as it is measured parallel to the line SN. In order to establish a record of the motion of the mandible in the plane of space which we are studying, we employ the following method.

On the tracing of the x-ray picture showing the mandible in the closed position, draw the mandible in this closed position with a solid line. At the

center of the condyle establish point C. On this same tracing, by means of a dotted line, also draw the mandible in its rest position. Call this Tracing 1.

Over Tracing 1, place another piece of tracing paper and on it trace the mandible in a closed position. Call this Tracing 2. Pierce both Tracing 2 and Tracing 1 at point C with the sharp point of a pin. Also pierce both tracings at the chin point Gn. Now shift Tracing 2 so that the mandibular image on it corresponds to the image of the mandible at rest position on Tracing 1. Pass the pin through the hole at point C of Tracing 2 and thus establish the point C′ on Tracing 1. Also pass the pin through the hole of point Gn, Tracing 2, and establish point Gn′ on Tracing 1. Now discard Tracing 2. On Tracing 1, project a line from C′ through C to SN. The distance C′ to C represents the distance the condyle moved from closed position to the position of rest. The angle C′ C SN represents the direction of movement. We may say, then, that the condyle has moved so many millimeters at so many degrees to SN. In like manner, project a line from Gn′ through Gn to SN. The distance Gn′ to Gn represents the distance the chin point has moved. This distance is often referred to as the freeway space, or occlusal clearance. The angle Gn′ Gn SN represents the direction of opening. We may say, therefore, that the chin point has opened so many millimeters at so many degrees to SN.

It will be noted that the mandible does not necessarily open vertically. It opens on a curve and this curve may be on either side of the vertical. This opening varies a great deal in different individuals and it often varies considerably during treatment. Even though we have not as yet established standards for these mandibular excursions, we are developing visual ones. We believe that the appraisal of these conditions is important and will receive increasing attention in the future.

We are well aware that there is an almost unlimited number of other measurements that could be made from cephalometric x-ray pictures, but we have restricted the number to these that you have just seen. We can honestly say that every one of those shown is used in our practice because we feel that there is a need for each of them.

Our reason for presenting this method to you is to share with others a method that in our hands has been satisfactory. We have found that with it the parents of our patients can be made to understand much more easily many of the problems involved. This is true because the tracings made by this method need but a minimum number of lines for the purpose they serve and because each of the various lines may be easily identified by its individual color, and finally because the readings and measurements are close to the areas to be judged.

This method does show simply and graphically some of the important points to be considered in case analysis. An example of its usefulness is shown in the following case (No. 2248).

This case (Fig. 8) appears to be typical of those showing a Class III tendency such as have often had compromised treatment by bringing the maxillary teeth forward. Let us see what our cephalometric appraisal of this case tells us.

The angle SNA (Fig. 9) should, according to the average, be 82 degrees, and it is 86 degrees. This means that point A on the maxillae is 4 degrees anteriorly placed according to our standards. Clearly then, this is not a case of marked underdevolpment of the maxillae. Let us look at the mandible. The angle SNB should be 80 degrees and it is 84 degrees, a difference of 4 degrees, and the error is in the same direction as the error of point A. Both are easily attributable to patient-type. This patient does not have a Class III face.

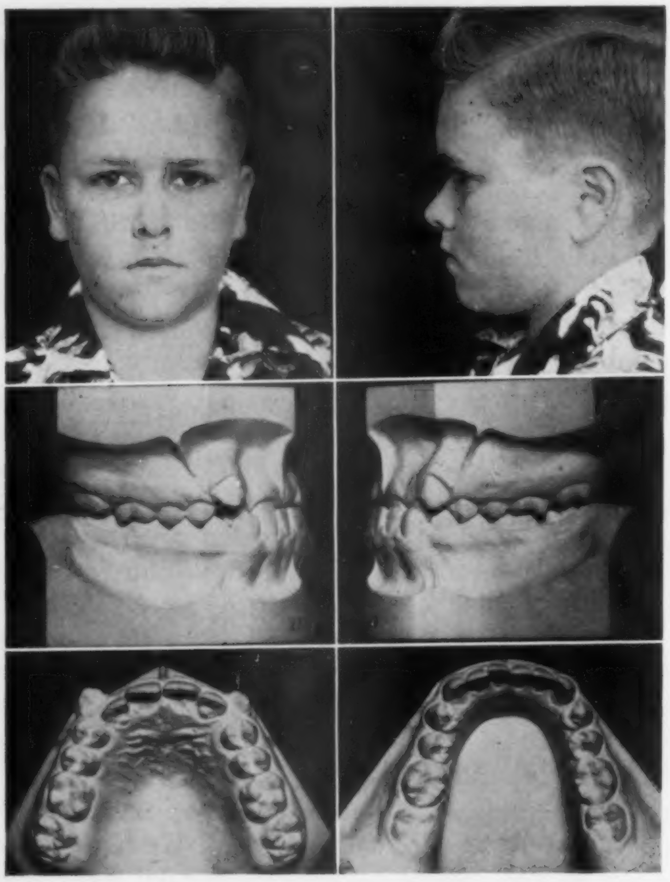
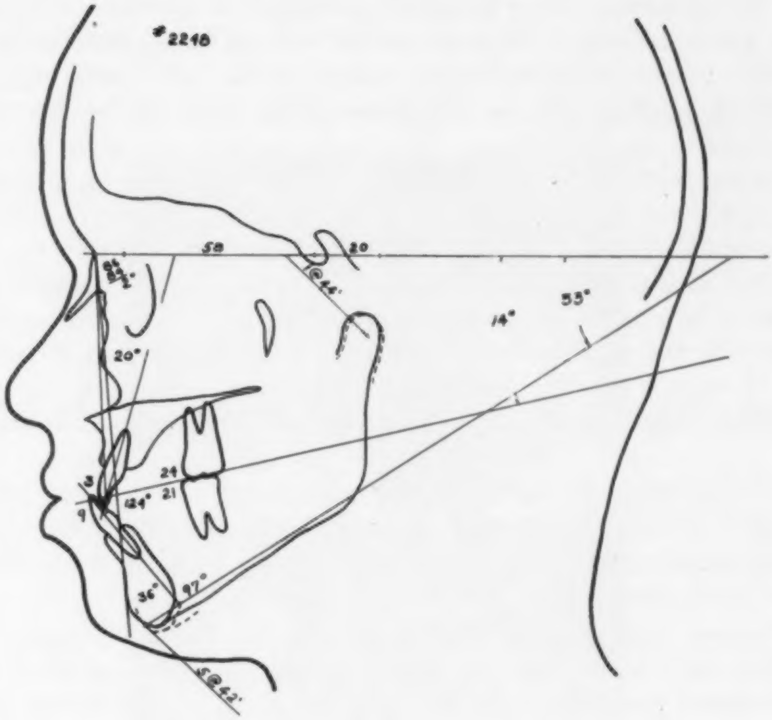


Fig. 8.—Case 2248. Note resemblance to Class III malocclusion.

What is the relationship of the mandible to maxillae as shown by the angles SNA and SNB (in reality the angle ANB)? This difference should be 2 degrees, and it is 2 degrees. The bony bases appear to be good. The angle GoGn SN is 33 degrees, being within 1 degree of what it should be (32 degrees), which reinforces this conclusion.

Let us now see how the denture is placed in its bony framework. The occlusal plane to SN should be 14½ degrees and it is 4 degrees. The denture is well placed in the head. Obviously the malocclusion is created by the teeth themselves, but where?



Name #2248 Date ______ Age 13:3

Cephalometric Appraisal

		Average	5-9-52	
S N A	(angle)	82	86	
S N B	(angle)	80	84	
Difference		2	2	
GoGn SN	(angle)	32	33	
CC' SN	(angle)		1 @ 44	
GnGn' SN	(angle)		5@42	
S to E	(mm)		20	
S to L	(mm)		58	
Occl to S N	(angle)	14.5	14	
$\underline{1}$ to $\overline{1}$	(angle)	130	124	
$\underline{1}$ to NA	(mm)	4	3	
$\underline{1}$ to NA	(angle)	22	20	
$\overline{1}$ to NB	(mm)	4	9	
$\overline{1}$ to NB	(angle)	25	36	
$\overline{1}$ to GoGn	(angle)	93	97	
$\underline{6}$ to NA	(mm)	27	24	
$\overline{6}$ to NB	(mm)	23	21	
Existing & Desired Arch Length Diff.			70 72.5 -2.5	

Fig. 9.—Case 2248. Cephalometric tracing and measurements.

Let us look at the upper incisors. According to our standards, the crown should be 4 mm. anterior to NA, and we find it to be 3 mm. anterior to it. That means that we may bring the upper central incisor forward 1 mm., but that would not do much in the way of correcting the posterior relationship of the upper incisors to the lower ones. How about the angulation of this upper incisor? Its angulation is 20 degrees to the line NA, and this measurement should be 22 degrees. Now let us look at the lower incisors. Here we find the culprits. These incisors should be 4 mm. in front of the line NB, and they are 9 mm. in front of it. Are they bodily forward, or are they tipped forward? Let us look. The axial inclination of these teeth should be registered at 25 degrees to the line NB, and it is shown on the tracing as 36 degrees. It should be registered at 93 degrees to the mandibular plane (GoGn), and this measurement is shown as 97 degrees. According to both measurements, the tooth is badly tipped forward.

Very obviously these teeth are badly misplaced, and to have followed the time-honored method of treatment in cases such as this, by moving the already fairly well-placed upper teeth forward in order to properly relate them to the misplaced lower teeth would have been a tragedy.

The correct treatment has now become obvious. The case presents "blocked-out" canine teeth in the maxillae, and the mandibular teeth are in a very much too far forward position, so there is just one answer: the extraction of four first premolars. We then can position the upper canines and move the lower teeth distally to a normal relationship with the upper ones by utilizing the spaces of the extracted premolars, and the treatment of the case has thus become relatively simple.

As evidence of the usefulness of this system of measurements for comparative purposes, we submit the following case reports and explanations of the methods we use to compare tracings. The before-treatment and after-treatment photographs and models of Case 2059 are shown in Fig. 10. Fig. 11 shows a cephalometric tracing representing the case before treatment. Fig. 12 represents it after treatment, and Fig. 13 shows the tracing of the case after twelve months of retention. In Fig. 14 is a chart of the measurements from these three tracings. Fig. 15 shows the before-treatment and after-treatment tracings superimposed on the line SN, registered at N. Fig. 16 shows the same tracings superimposed on the maxillae, on the symphysis of the mandibles, on the condyles of the mandibles, and on the lines SN, registered at S. Fig. 17 is a superposition of the after-treatment tracings and the after-retention tracings. Fig. 18 shows a comparison of the tracings of the case before treatment was started and after it had nineteen months of treatment and twelve months of retention.

This case was selected because it presents many of the troublesome and bewildering problems encountered in the treatment of malocclusions (Fig. 11). It has a mandibular angle (GoGn-SN) or 37 degrees instead of the average of 32 degrees. The difference of the angles SNA and SNB is 7 degrees instead of 2 degrees, meaning that the lower jaw is approximately 5 degrees distally placed to normal. The condyle, instead of rotating on an axis in or near the

condyle, moves 7 mm. downward and forward at 135 degrees to the line SN, when opening from closed position to rest position.

The literature is full of confusion concerning this type of jaw closure, some believing that in a case such as this the condyle is closed distally to its

Fig. 10.—Case 2059. Photographs taken before and after treatment.

normal position because of cuspal interference, and therefore they refer to it as "a bite of convenience." In this case, the distance SE is relatively large and the distance LS is relatively small, which might indicate the presence of such

Let us look at the upper incisors. According to our standards, the crown should be 4 mm. anterior to NA, and we find it to be 3 mm. anterior to it. That means that we may bring the upper central incisor forward 1 mm., but that would not do much in the way of correcting the posterior relationship of the upper incisors to the lower ones. How about the angulation of this upper incisor? Its angulation is 20 degrees to the line NA, and this measurement should be 22 degrees. Now let us look at the lower incisors. Here we find the culprits. These incisors should be 4 mm. in front of the line NB, and they are 9 mm. in front of it. Are they bodily forward, or are they tipped forward? Let us look. The axial inclination of these teeth should be registered at 25 degrees to the line NB, and it is shown on the tracing as 36 degrees. It should be registered at 93 degrees to the mandibular plane (GoGn), and this measurement is shown as 97 degrees. According to both measurements, the tooth is badly tipped forward.

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This case was selected because it presents many of the troublesome and bewildering problems encountered in the treatment of malocclusions (Fig. 11). It has a mandibular angle (GoGn-SN) or 37 degrees instead of the average of 32 degrees. The difference of the angles SNA and SNB is 7 degrees instead of 2 degrees, meaning that the lower jaw is approximately 5 degrees distally placed to normal. The condyle, instead of rotating on an axis in or near the

condyle, moves 7 mm. downward and forward at 135 degrees to the line SN, when opening from closed position to rest position.

The literature is full of confusion concerning this type of jaw closure, some believing that in a case such as this the condyle is closed distally to its

Fig. 10.—Case 2059. Photographs taken before and after treatment.

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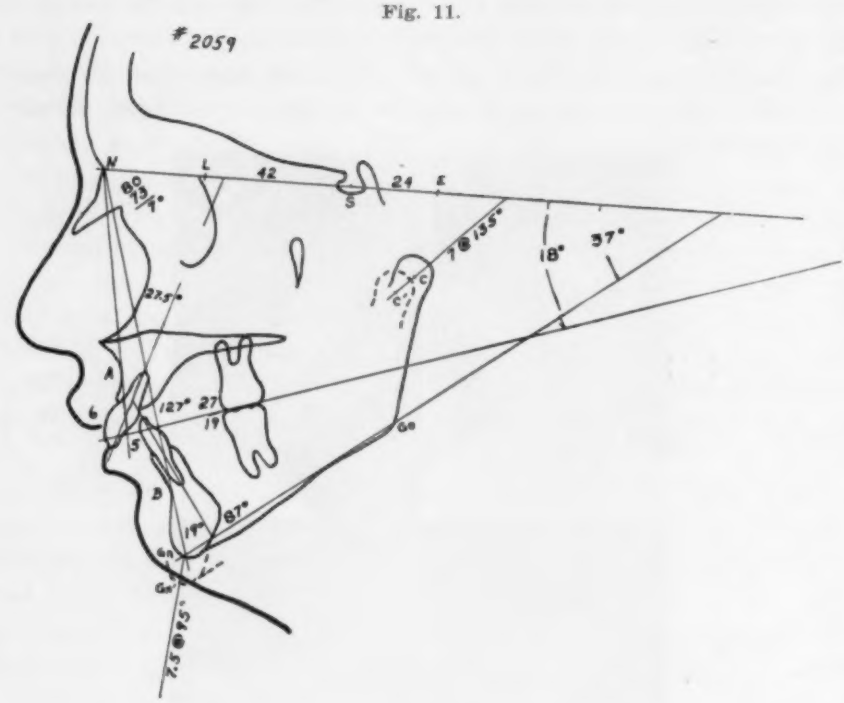
Fig. 11.



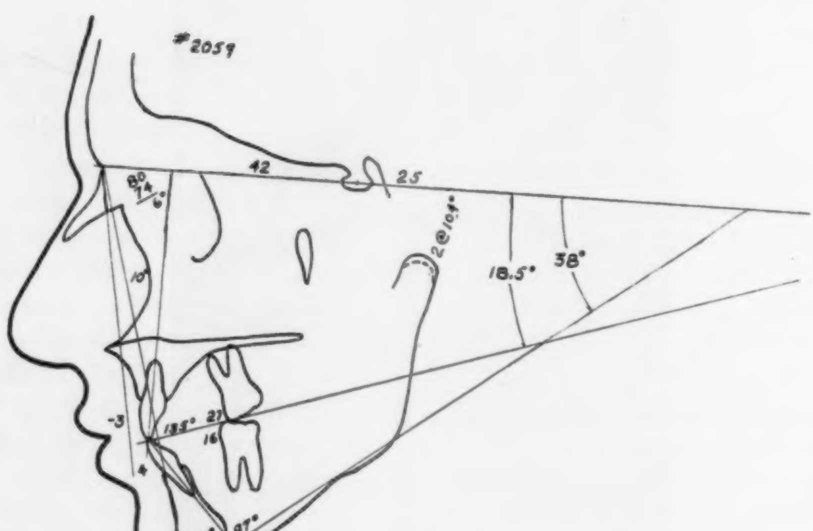


Fig. 12.

Fig. 11.—Tracing of Case 2059 before treatment.
Fig. 12.—Tracing of Case 2059 after treatment.

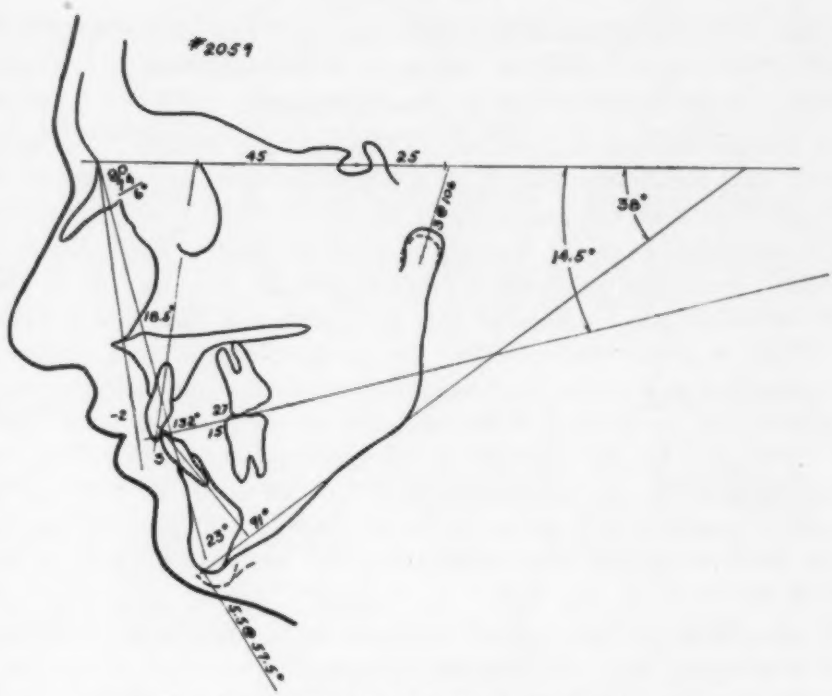


Fig. 13.—Tracing of Case 2059 after retention.

Name #2059 Date Age 13:1

Cephalometric Appraisal

		Average	9-5-50	6-5-52	1-28-53
S N A	(angle)	82	80	80	80
S N B	(angle)	80	73	74	74
Difference		2	7	6	6
GoGn SN	(angle)	32	37	38	38
CC' SN	(angle)		7@ 135	2@ 104	3@ 106
GnGn' SN	(angle)		7.5@105	4.5@58.5	5.5@57.5
S to E	(mm)		24	25	25
S to L	(mm)		42	42	45
Occl to S N	(angle)	14.5	18	18.5	14.5
$\underline{1}$ to $\overline{1}$	(angle)	130	127	135	132
$\underline{1}$ to NA	(mm)	4	6	-3	-2
$\underline{1}$ to NA	(angle)	22	27.5	10	18.5
$\overline{1}$ to NB	(mm)	4	5	4	3
$\overline{1}$ to NB	(angle)	25	19	29	23
$\overline{1}$ to GoGn	(angle)	93	87	97	91
$\underline{6}$ to NA	(mm)	27	27	27	27
$\overline{6}$ to NB	(mm)	23	19	16	15
Existing & Desired Arch Length Diff.			65 70 -5		

Fig. 14.—Case 2059. Chart showing measurements taken from tracings shown in Figs. 11, 12, and 13.

a condition. The over-all distance LE is evidence of a relatively small mandible. The angle SNB by our standards should be 80 degrees, it is 73 degrees—more evidence of a small mandible and its distal placement.

Now let us consider the method of comparing tracings. The landmarks most often used for superimposing on the maxillae for the purpose of measuring the movements of the maxillary teeth are the upper and lower surfaces, and the anterior and posterior terminal ends of the palate. The superior surface of the palate is extremely difficult to trace accurately, as evidenced by the great variance we see in the tracings of this structure, and therefore it is of little value. There is ample evidence that the curve of the lingual surface of the palate is modified as a result of orthodontic treatment, thus ruling it out except as supplementary evidence. X-ray pictures of the anterior nasal spine are largely influenced by the manner in which they are taken. The posterior terminus of the palate is a growth center and changes rapidly during the growing years. We believe that our method contributes to the possibilities of superimposing these structures more accurately and more usefully than has been possible in the past.

All changes in the positions of anatomic parts must be expressed in terms of their relationship to something else. If we desire to record changes due to orthodontic treatment alone, we must offset, or at least minimize, the records of the changes that are due to growth in the areas we wish to judge. To do this we must superimpose on those certain structures from which we want to measure, and observe how the structures to be judged vary in relationship to these superimposed structures and to each other. For example, if we are to judge whether or not we have moved teeth in the maxillae, we must superimpose on the maxillae and let the growth changes be recorded elsewhere. If we want to judge how much the teeth have moved in the mandible, then we must superimpose upon the mandible and upon that portion of it which will serve our purpose. But how are we to superimpose maxillae or mandibles that have been growing and no longer fit each other? It is obvious that we need additional information to supplement that which is available in these bones themselves, for they are no longer identical in size or shape. Let us now see whether or not this system of measurements is helpful to this end.

We are primarily interested in changes that have occurred in the face, so we will diminish evidence of growth changes in the facial area by superimposing upon the lines SN at N (Fig. 15), thus causing the lines NA to superimpose. The record of the anterior-posterior growth changes thus will be expressed elsewhere. Changes in both growth and tooth movement may now be observed throughout the denture as judged from the lines SN and NA. By this superposition we also can judge visually and graphically any relative changes in the position of the mandible in its relation to the maxillae. The anteroposterior relationship is expressed by the angle ANB. We are going to come back to the changes in the mandible later, by another method.

Let us now also minimize the evidence of vertical growth changes in the region of the maxillae by raising the second tracing vertically along the line

NA, thereby keeping the lines SN of both drawings parallel until, by the greatest amount of evidence in the region of the maxillae, the structures of the first and second drawings of the maxillae are superimposed (Fig. 16). The movement of the maxillary teeth in the maxillae can now be assessed. To judge the movement of the mandibular teeth in the mandible, we know of no better way than to superimpose on the cross section of the symphysis, keeping the lower borders of the mandibles parallel (Fig. 16). In order to assess any changes in the location of the mandible and its relationship to the other structures of the head, let us superimpose the line SN, registered at S (Fig. 16). By this

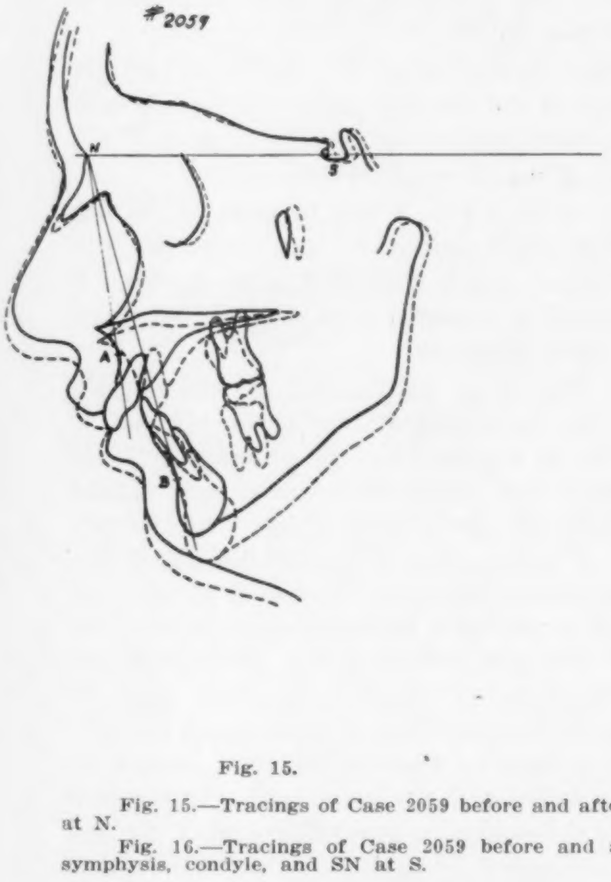


Fig. 15.

Fig. 16.

Fig. 15.—Tracings of Case 2059 before and after treatment superimposed on SN registered at N.

Fig. 16.—Tracings of Case 2059 before and after treatment superimposed on maxillae, symphysis, condyle, and SN at S.

method, evidence of growth changes will be minimized in this region and the points E representing the projections of the most distal points on the condyles will be registered in relationship to each other along the lines SN. In like manner, the points L, being projections of the most anterior points of the bodies of the mandibles (pogonion), will be represented along the line SN, and can be compared.

Distances between the points L and E of the respective drawings will represent the anterior-posterior lengths of the mandibles parallel to the line

SN, which is roughly the anterior-posterior direction. Let it be noted that this measurement does not necessarily represent the change in the length of the body, for the mandible does not necessarily lie parallel to the line SN, and as the bite is opened this measurement is effected. Its measurement in this direction is dependent upon its degree of parallelism to the line. It does represent the thing that we are interested in, mainly "Has Willie's chin come forward, or has it gone backward?"

By superimposing the mandibles at the symphysis (Fig. 16), the lines representing the motion of the chin point can be compared. Comparisons of the difference in motion in the condyles can be made in the same manner by superimposing the condyles (Fig. 16). Let us now apply these principles to the tracings of this case and see what they tell us.

By looking at the before-treatment tracing (Fig. 11), we learn that the upper central incisor is 6 mm. in front of the line NA instead of being 4 mm. in front of it, as it should be. The axial inclination is 27½ degrees to NA instead of being 22 degrees, thus showing that it is tipped forward.

Let us look at the lower incisor. It should be 4 mm. in front of the line NB, and it is 5 mm. in front of it, being only 1 mm. too far anterior to this line. Its inclination to the line NB is 19 degrees, and it is entitled to 25 degrees. It is at 87 degrees to the GoGn plane instead of a normal of 93 degrees, and therefore, by both standards, it is tipped back 6 degrees.

The plane of occlusion is at 18 degrees to the line SN instead of 14½ degrees. Upon opening to rest position, the gnathion point moves 7½ mm. at 95 degrees to SN. Instead of rotating on a point in or near the condyle, the condyle moves from rest position upward and backward to a position of closure which might be claimed to be an abnormally distal position or a "bite of convenience." This is the type of case of which it has been correctly stated that an ideal result can never be achieved because the basic framework for an ideal result is absent, and probably cannot be provided by orthodontic means. Because the mandibular dental arch is crowded, lacking 5 mm. of desired arch length, and because to pull forward against it with intermaxillary ligatures would have complicated this crowding further, we chose to extract four first premolars, accept the mandibular position close to where it was, and retract the maxillary teeth to a harmonious relationship with the lower teeth. In the light of changing thought and treatment philosophy in our office during the last several years, we now might have attempted treatment of this case without extraction by using occipital anchorage exclusively.

The tracings (Figs. 7 to 11) will give evidence of what was accomplished. In all of these drawings, the angle SNA and the line NA are transferred from the first drawing to subsequent drawings. Let it now be stressed that point A on the maxillae is not a constant point. It changes not only as a result of normal growth but also as a result of orthodontic treatment. For this reason we use the angle S N A as established on the first tracing for all subsequent tracings. It is the yardstick by which all tracings for this particular case will be assessed.

Let us now compare the tracings of this case. Specifically, what do we want to know about it? The most important questions are, "What changes have taken place in the relationships of the lower jaw to upper jaw, what changes have occurred in the jaws themselves, what movement of the maxillary teeth has taken place in the maxillae, and what movement has there been of the mandibular teeth in the mandible? Equally important, what change has there been in the functional movements of the mandible?" I challenge you to find answers to these questions in a plaster model.

Fig. 17.

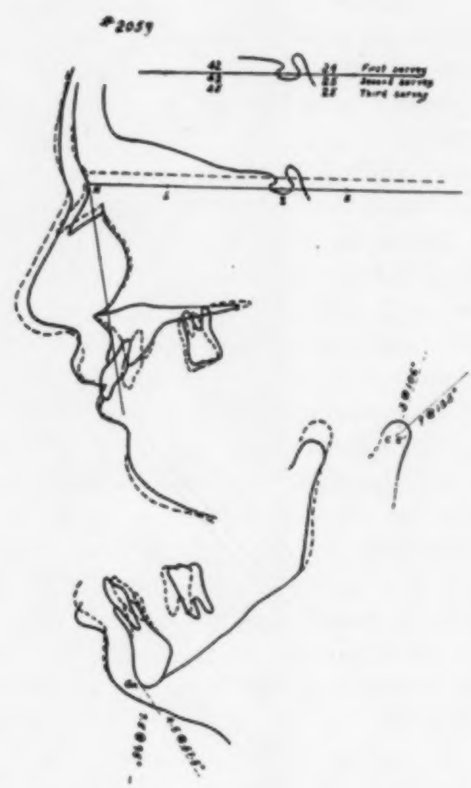


Fig. 18.

Fig. 17.—Tracings of Case 2059 after treatment and after retention superimposed on maxillae, symphysis, condyle, and SN at S.

Fig. 18.—Tracings of Case 2059 before treatment and after retention superimposed on maxillae, symphysis, condyle, and SN at S.

Let us see first what has happened to the chin during treatment (Figs. 11 and 12). The difference of the angles SNA and SNB is 6 degrees, having been reduced 1 degree, meaning the chin has come forward 1 degree, which certainly is not very much. The lower molar, which was 19 mm. behind the line NB, is now 16 mm. behind it. It has come forward 3 mm. The lower incisor, which was 5 mm. ahead of the line NB, has come backward 1 mm. to the desired position of 4 mm. Its inclination is forward 4 degrees of its desired position.

Let us look at the upper jaw. The molar was 27 mm. back of the line NA, and it is still 27 mm. It has been held in its original position. The incisors were 6 mm. ahead of NA, and they are now 3 mm. distal of it. The tooth, therefore, has been moved distally 9 mm., and our diagnostic aim apparently has been well accomplished.

Now let us quickly look at some other things that are interesting. The occlusal plane was 19 degrees, and it is now 18½ degrees, having been held almost constant. GoGn to SN has increased 1 degree. This is due to opening of the bite.

Let us see what has happened to the position of the mandible. The distal point of the condyle projected to the line SN (point E) is now 25 mm. from S, instead of 24 mm. The condylar head has gone back 1 mm. The chin point projected to the line SN is still 42 mm. from S; the over-all length LE has increased 1 mm. only. The mandible undoubtedly has grown, but it also has opened, and the chin point has remained almost constant in an anterior-posterior direction.

Let us see what has happened to the motion of the mandible. The condyle now opens to rest position by moving 2 mm. at 104 degrees to the line SN instead of 7 mm. at 135 degrees, a very much more normal motion. The chin point now moves downward and backward 4½ mm. at 58½ degrees to SN, obviously a much more normal movement.

Make the same comparisons of the tracings after treatment (Fig. 12) to those representing the case after twelve months of retention (Fig. 13). The lower incisor has corrected itself to very close to a normal position. The other teeth that were tipped too far have done much to right themselves. The plane of occlusion not only has recovered its original position, but it has flattened down to a completely normal relationship to the line SN. The mandible has put on a growth spurt of 3 mm. The condyle has moved forward 1 mm. The chin point has come forward 3 mm. It may be wishful thinking, but I believe that normal function is rapidly contributing to the recovery of the malformed framework.

To many of you who continue to say, "Why use a cephalometer? Its use would not alter my clinical treatment," we submit evidence of Case 2171 (Figs. 19 to 27), which was treated by the time-honored method of using intermaxillary elastics to correct the Class II relationship. Every possible attempt was made to provide sufficient anchorage in the anchor teeth and to move those teeth which we desired to move. By means of the methods of assessment just outlined, it will be seen that the upper molars have moved distally 4 mm. The upper incisor has been moved 8 mm. and has been erected 19½ degrees. The price in anchorage paid for this distal movement of the upper teeth was the forward movement of the lower molar 3 mm. and of the lower incisor 4 mm., and a forward tipping of the lower incisor 13 degrees. This means that this lower tooth is 4 mm. in front of its normal position, and 19 degrees forward of its normal axial inclination. The plane of occlusion has paid a heavy price, having been tipped an additional 11 degrees from normal.

Examine Figs. 22 and 23 and be grateful to the Supreme Benefactor who does His best to take care of all of us, even the orthodontist. In this picture,

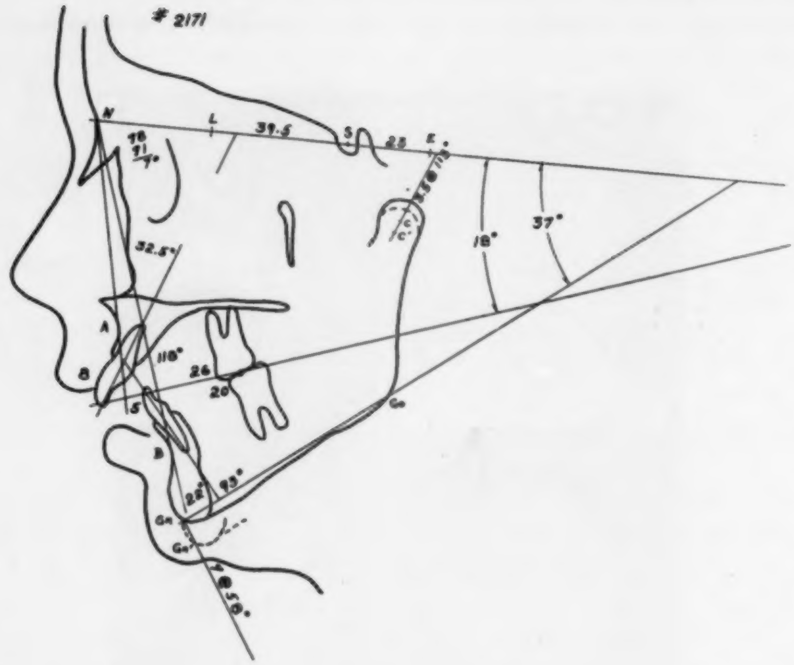
taken after the retention period, the lower incisor has recovered 9 degrees from its bad axial inclination and 3 mm. of its forward position to a correct position. The position and motion of the mandible have been very nearly normalized, and

Fig. 19.—Case 2171. Photographs taken before and after treatment.

even though the ANB angle is still 7 degrees instead of being 2 degrees, as we might wish it, I believe that the treatment has been satisfactory under the circumstances.

We wish to point out that the cephalometric appraisal of this case has shown clearly and impressively the price in anchorage that intramaxillary pull

Fig. 20.



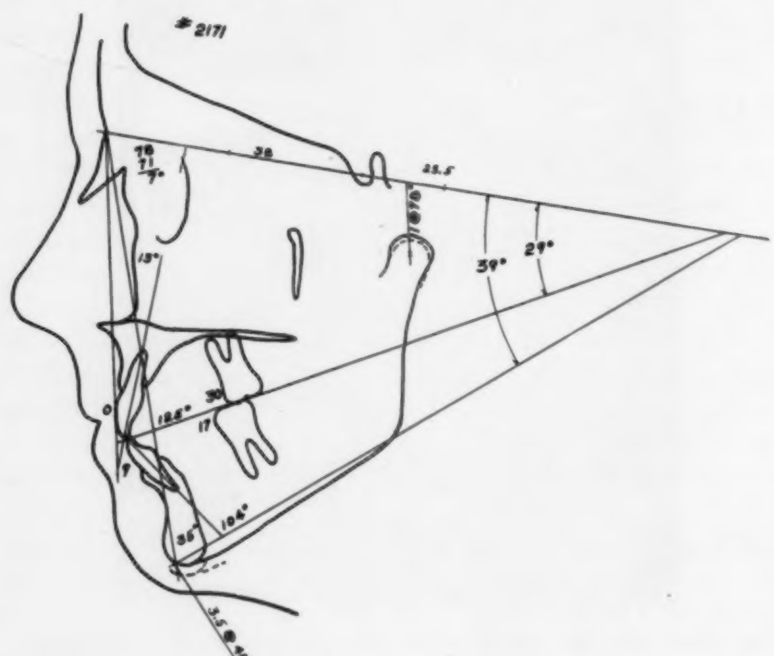


Fig. 21.

Fig. 20.—Tracing of Case 2171 before treatment.
Fig. 21.—Tracing of Case 2171 after treatment.

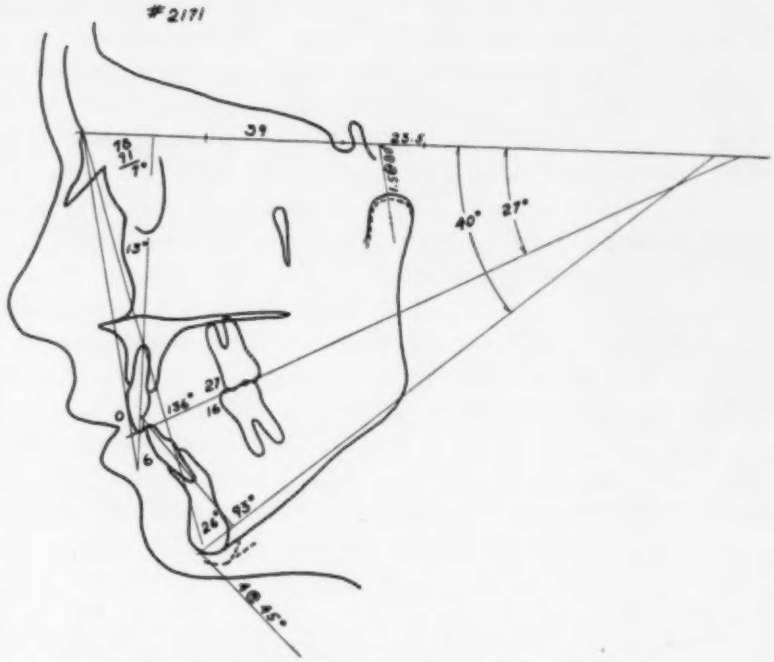


Fig. 22.—Tracing of Case 2171 after retention.

Name #2171 Date ______ Age 11:3

Cephalometric Appraisal

		Average	8-9-50	1-23-52	2-7-53
S N A	(angle)	82	78	78	78
S N B	(angle)	80	71	71	71
Difference		2	7	7	7
GoGn SN	(angle)	32	37	39	40
CC' SN	(angle)		3.5@113		1.5@80
GnGn' SN	(angle)		7@58		4@45
S to E	(mm)		23	23.5	23.5
S to L	(mm)		39.5	38	39
Occl to S N	(angle)	14.5	18	29	27
$\underline{1}$ to $\overline{1}$	(angle)	130	118	125	136
$\underline{1}$ to NA	(mm)	4	8	0	0
$\underline{1}$ to NA	(angle)	22	32.5	13	13
$\overline{1}$ to NB	(mm)	4	5	9	6
$\overline{1}$ to NB	(angle)	25	22	35	26
$\overline{1}$ to GoGn	(angle)	93	93	104	93
$\underline{6}$ to NA	(mm)	27	26	30	27
$\overline{6}$ to NB	(mm)	23	20	17	16
Existing & Desired Arch Length Diff.			67 / 67 / 0		

Fig. 23.—Case 2171. Chart showing measurements taken from tracings shown in Figs. 21, 22, and 23.

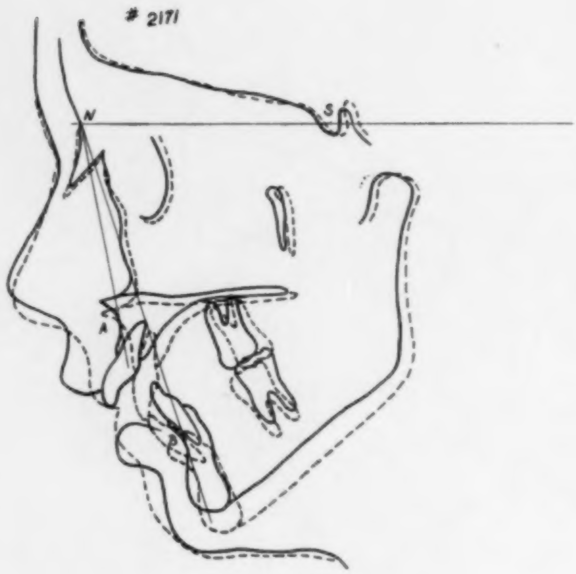


Fig. 24.

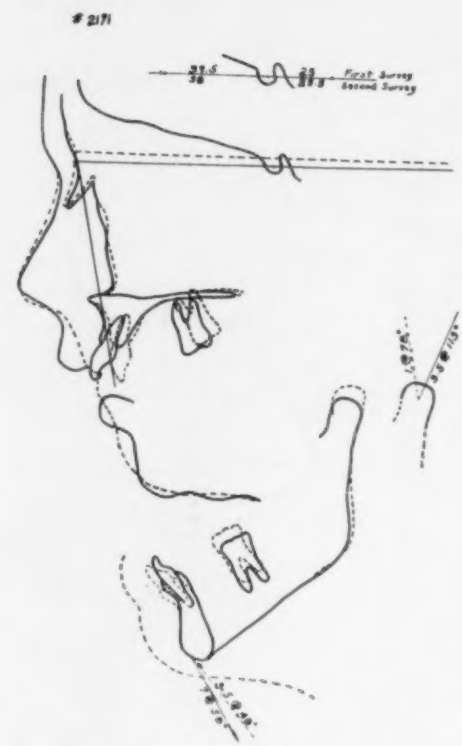


Fig. 25.

Fig. 24.—Tracings of Case 2171 before and after treatment superimposed on SN registered at N.

Fig. 25.—Tracings of Case 2171 before and after treatment superimposed on maxillae, symphysis, condyle, and SN at S.

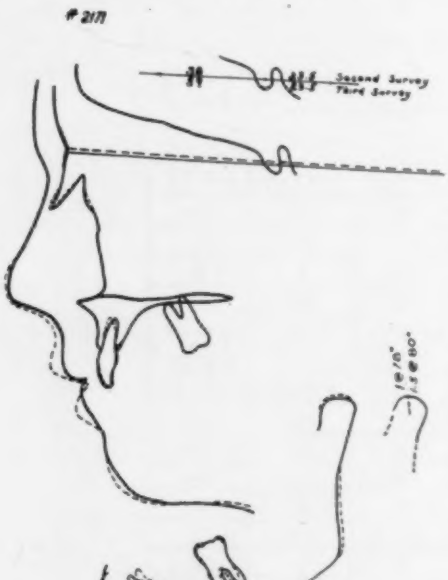


Fig. 26.

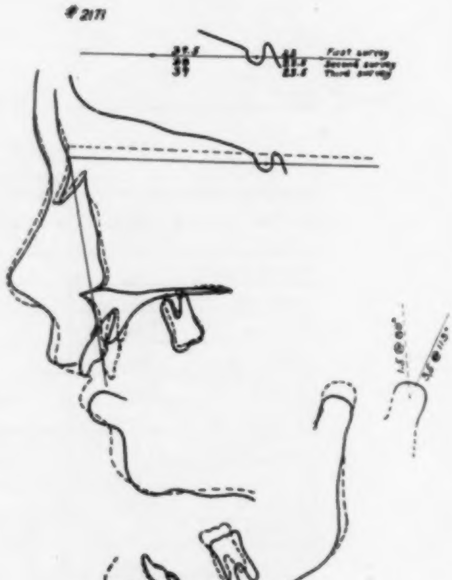


Fig. 27.

Fig. 26.—Tracings of Case 2171 after treatment and after retention superimposed on maxillae, symphysis, condyle, and SN at S.

Fig. 27.—Tracings of Case 2171 before treatment and after retention superimposed on maxillae, symphysis, condyle, and SN at S.

exacts from the anchor teeth. Examples such as these do crystallize the thinking of those orthodontists who use the cephalometer. I am sure that it does contribute to their diagnostic judgment.

As previously stated, we have chosen from those methods of cephalometric assessment that were available measurements that we feel are useful for our needs. To these we have added others that have been useful to us. To have attempted to give complete individual credit for the established methods would have been a Herculean task, and a dangerous one because as is the case of most progress, many of these ideas did not come spontaneously from a single mind, but were evolved by the thinking of others.

Our method is not proposed to replace any that have already been suggested. It is reported because it serves us well and because of our belief that tracings made in this way are simpler and less confusing, particularly to parents and to others who may view them.

The cephalometer is here to stay as a tool of the clinical orthodontist. It is our hope that the suggestions made in this article will help to convince others of the importance of the cephalometer and of its potentialities as a diagnostic instrument.

I wish to express my appreciation to Dr. Fred J. Angel for his valuable assistance in preparing the illustrations for this article.

153 S. Lasky Dr.

INCIDENCE OF CARIES DURING ORTHODONTIC TREATMENT

E. N. Bach, A.B., D.D.S., Toledo, Ohio

I. INFORMATION OBTAINED ON THE TEETH OF CHILDREN RECEIVING NO ORTHODONTIC TREATMENT

DENTAL caries, no doubt, exceeds in prevalence all other physical defects in children, and to date there appears to have been little advance made in arresting or preventing this disease.

While we know the old saying that "a clean tooth does not decay" is not true, neither is the statement true that filthy or unhygienic teeth decay rapidly when they are so often found covered with food material for days at a time.

There are always exceptions, to be sure. One may assume, and quite correctly, that "clean teeth" are subject to less caries experience than unhygienic teeth; and, conversely, teeth given but little prophylactic care are wide open to external destructive forces. This brings us to the present situation.

How far have we advanced in the actual prevention of dental caries? What studies have been undertaken, research projects conducted, and experiments made in prevention or control of caries? We all are aware of, and some are intensely interested in, this work being carried on by many investigators and colleges for whom we all share our gratitude, and they should be encouraged in their uphill endeavors.

Brushing teeth is not the answer; cleaning teeth approaches the solution. Nutrition, as well as the possibility of hereditary tendencies toward caries experience, no doubt plays a vital part. This is my belief after checking over many thousands of teeth and correlating these findings with the care they have received, including the nutrition of the mother during pregnancy and that of the patient up to the time of dismissal from our care.

In discussing this subject and the changes (caries and decalcifications) which take place on the enamel during orthodontic treatment, we have found many interesting angles and facts which to my knowledge have never been recorded and put into print.

For example, we have made a number of charts listing all of the teeth by number showing the status of caries, fillings, and the various types of decalcification. Teeth are listed in decreasing order of caries and surfaces involved (decalcified areas such as spots and lines on the surfaces, and the various findings of our experience covering an average of 4.2 years while patients were under our observation and treatment.

Before going into this phase of the article we have felt it best to ascertain to some degree that which takes place in the mouths of young people between 6 and 15 years of age who have had no orthodontic treatment, in order to

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evaluate our findings of, or make comparison with, the teeth of those who have been under orthodontic care.

Many studies have been made by such men as Drs. Klein, Carroll, Palmer, T. J. Hill, Bunting, Knutson, Jay, Arnold, and many others, and many statements made in the first part of this article are quotations, or are based directly on the summary of their findings.

"Tooth mortality" is cumulative with respect to chronological age. That is, as age increases there is a corresponding increase in DMF (decayed, missing, or filled) teeth, which was found by Klein and Palmer in checking over 4,416 school children in Hagerstown, Md. Figures in all tables relate to permanent teeth only.

TABLE I. A COMPOSITE CHART FROM A NUMBER OF CHARTS BY KLEIN, PALMER, AND KNUTSON[1] OF 4,416 ELEMENTARY SCHOOL CHILDREN, HAGERSTOWN, MD.

1	2	3	4	5	6	7	8	9
AGE (YEARS)	PERMANENT TEETH PRESENT	D M F PERMANENT TEETH	CARIES (C)	CARIOUS TEETH	TEETH FILLED	FILLINGS (F)	D M F SURFACES	TEETH REQUIRING FILLINGS
6	1593	95	103	81	13	17	125	46
7	3350	293	325	259	25	27	406	137
8	5452	583	591	458	110	122	835	226
9	6883	994	1146	732	213	273	1864	294
10	9064	1329	1350	875	347	452	2575	329
11	11363	1510	1365	946	455	591	2758	349
12	14401	2179	1945	1315	684	945	4255	422
13	14138	2478	2211	1429	770	1026	5068	396
14	9673	1898	1809	1257	453	604	3854	297
15	3751	913	957	637	171	225	2013	121
Total	79668	12272	11802	7989	3241	4282	23753	2617
Averages per child			2.7	2.8	.73	.99	5.5	.59

The percentage of total surfaces involved is 31 per cent.

The actual average number of fillings per child will equal the sum of the averages of the following columns:

Column 4—caries	2.7
Column 7—fillings	0.99
Column 8—DMF surfaces	1.0 (1 surface per child)
Column 9—needed fillings	0.59
	5.28 or approximately 5¼ average F per child.

It is a conservative estimate that one of the DMF surfaces per child will become carious, needing a filling, within the next few years.

This means that in 6-year-olds approximately 16 per cent of the permanent teeth in both boys and girls are carious.

As age increases, permanent teeth likewise increase in number up to about 15 years of age, when approximately 95 per cent of the children have one or more carious teeth.[3]

Of the 4,416 children aged 6 through 15 years, 3,156 or 71.5 per cent show a history of caries in one or more permanent teeth.[3]

There are 79,668 permanent teeth present in the 4,416 children. Of the 79,668 teeth, 23,753 DMF surfaces are present in 12,272 teeth, or approximately 30 per cent DMF surfaces for permanent teeth present.[3]

There is an average of eighteen permanent teeth present in each child, which would total approximately five and one-half carious surfaces per child.

DMF permanent teeth in girls are as much as 20 per cent higher than in boys. It will be noted that at the age of 13 the crest of most increases appears to have been reached, followed by a decline in number of both teeth and tooth surfaces involved.

That there is an order or sequence in the kind of tooth which is attacked by caries and the number of surfaces involved is shown by the figures in Table II.

TABLE II*

TEETH INVOLVED IN DECREASING ORDER		NO. OF SURFACES INVOLVED	EACH TOOTH CONSIDERED AS POSSESSING 5 SURFACES. % OF SURFACES INVOLVED
1st mandibular	1st molars	12232	87.3
2nd maxillary	1st molars	6222	65.3
3rd maxillary	central incisors	1197	12.3
5th maxillary	lateral incisors	1021	8.9
4th mandibular	2nd molars	871	7.2
6th maxillary	1st premolars	512	5.2
7th maxillary	2nd premolars	472	4.9
8th maxillary	2nd molars	394	4.1
9th mandibular	2nd premolars	397	2.8
10th mandibular	central incisors	150	1.2
11th mandibular	lateral incisors	107	.8
12th mandibular	1st premolars	101	.7
13th maxillary	canines	69	.7
14th mandibular	canines	8	.5
	Average	23,753	201.9
		1,696	Average 14.3

*From Klein, Henry, Palmer, Carroll E., and Knutson, John W.[1]

From this table the following facts are available:

The mandibular first molar teeth show the greatest number of surface defects.

Approximately 91 per cent of all carious or filled permanent tooth surfaces are found in the maxillary and mandibular first molars, mandibular second molars, and maxillary central and lateral incisors.

Sixty-four per cent of caries in the maxilla and 87 per cent of the caries occurring in the mandible are due to the first molars, while the teeth least affected are the maxillary and mandibular canines.

It is also interesting to note the surfaces which are affected and the order in which they are involved. The data in Table III are taken from the same group of children.[1]

These same investigators found that 43 per cent of the total surface defects occur in the occlusal surface, 31 per cent in the mesial and distal surfaces, and 26 per cent in the buccal and lingual surfaces.[1]

Table IV is a portion of table from the same survey of 4,416 children in Hagerstown, Md., made by Drs. Knutson, Klein, and Palmer.[3] It shows in decreasing order the specific kinds of permanent teeth which contribute to

TABLE III

SURFACE	NO. OF SURFACES INVOLVED	PER CENT OF TOTAL SURFACES INVOLVED
Occlusal	4951	42.8
Mesial	2014	17.4
Distal	1657	14.3
Buccal	1503	13.0
Lingual	1434	12.4
	Average 19.9 per cent	

total caries experience. These figures were taken on boys; those of girls run in a similar pattern.

As one will note, in all ages throughout the table, the mandibular first molar tooth maintains first position and the maxillary first molar, second position. The maxillary central and lateral incisors maintain third and fourth positions through the age of 12. From then on the maxillary and mandibular second molars take their places, the maxillary central and lateral incisors shifting their position lower in the scale with the variation in position of the bicuspids. The cuspids hover around the last position of least caries experience.

TABLE IV*

6 YEARS	8 YEARS	10 YEARS	12 YEARS	15 YEARS
L 1st molar	L 1st molar	L 1st molar	L 1st molar	L 1st molar
U 1st molar	U 1st molar	U 1st molar	U 1st molar	U 1st molar
	U central incisor	U central incisor	U central incisor	U 2nd molar
	U lateral incisor	U lateral incisor	L 2nd molar	U 2nd molar
	U 1st bicuspid	U 1st bicuspid	U lateral incisor	U central incisor
	L 2nd bicuspid	L 2nd bicuspid	U 2nd bicuspid	U lateral incisor
		U 2nd bicuspid	U 1st bicuspid	U 2nd bicuspid
		L central incisor	U 2nd molar	U 1st bicuspid
		L lateral incisor	L 2nd bicuspid	L 2nd bicuspid
		L 1st bicuspid	L lateral incisor	L lateral incisor
		L 2nd molar	L central incisor	L central incisor
		L cuspid	L 1st bicuspid	U cuspid
		U cuspid	U cuspid	L 1st bicuspid
			L cuspid	L cuspid

*After Knutson, Klein, and Palmer,[3] omitting intervening years.

From this same group, Drs. Klein, Palmer, and Knutson, we note that of the total number of teeth present, 12,272 (which represent 61,160 surfaces), 23,753 surfaces were found carious; or approximately 31 per cent of all the five surfaces of the 12,272 permanent teeth present were carious. Through all of these investigations we found no specific mention made regarding decalcified areas, such as decalcified surfaces, lines, or spots. We have found from our records that it is from these etched or disintegrated surfaces that a large number of caries develop in later years.

As previously stated, tooth mortality is cumulative with respect to chronological age.

The attack on the teeth by caries is often related to duration and exposure. That is, the amount of destruction of a tooth by caries may be dependent upon

the length of time the tooth is exposed in the mouth after eruption. It is a well-established fact that dental caries progressively increases with advancing years.

"Girls erupt all permanent teeth earlier than boys, and girls likewise have a higher tooth mortality rate than boys."[3]

Other data have been brought out by Klein and Palmer which we believe will be of interest to our readers, although they have no direct bearing upon comparisons to be made later on incidence of caries under orthodontic treatment. This has to do with "Familial Resemblance in the Caries Experience of Siblings."[2]

In checking the familial characteristics of dental caries of 4,416 white children in Hagerstown, Md., the children were divided into two groups, one being relatively immune to caries, the other very prone to caries and showing relatively high caries susceptibility. Relatives of the brothers and sisters of grade school age of the immune and the susceptible groups were assembled and analyzed to show the level of caries in the two contrasted groups of siblings. The result of the analysis indicated siblings of susceptible parents have somewhat over twice as many caries in both permanent and deciduous teeth as do the siblings of the immune children.

Another fact of interest brought forth in these investigations is in relation to the time of eruption of permanent teeth and caries experience. The earliest eruptors show a very much higher caries attack rate than do the late eruptors, and it is believed that the early erupting teeth have been exposed to the risk of caries for a longer period than the late eruptors.

It has also been found that girls show no greater susceptibility to caries than do boys, when investigated at like eruptive ages.

May we repeat again the number of permanent teeth affected by caries per person increases progressively with advancing chronological age. By 10 years of age children show an average of 2.5 permanent teeth with evidence of caries experience. At 18 years of age these persons have accumulated nine DMF permanent teeth per person.

By age 15 more than 95 per cent of boys and girls have one or more carious teeth. Caries in individual teeth increases very sharply from 6 to 22 years; then there is a slight tapering off at around 40 years, and a decided decrease to 70 years of age.

The following data are recorded from 8,410 office employees of a manufacturing company (Hollander and Dunning) in New York City. The surfaces attacked ran from thirty-one in the 20 to 24 year group to seventy in the group aged 65 and over.

One can see from these data that there is a definite increase in caries experience of tooth surfaces per person with advancing chronological age.

In passing, may we inject this bit of information which is interesting but not of particular value as far as the subject matter of this article is concerned. From the results of examinations of approximately 5,000 white and 350 Negro

children in Hagerstown, Md., and 800 white and 1,400 Negro children in Baltimore, Md., by Klein and Palmer, 8,000 American Indian children by Klein and Palmer, and approximately 4,000 white children in San Francisco by Sloman and Sharp, it was found that at the age of 10 the Hagerstown and Baltimore white children show an average of a little more than 2.5 DMF teeth per person, while the Negro children in these cities show only 1.6 DMF teeth per person. The aggregate of Indian children of the same age showed only 0.5 DMF teeth per child.

Just another point in reference to the Indian groups. It was found that Indians living in high altitudes where there were the least number of days of fog and greatest amount of sunlight showed lowest caries rate. (Southwestern Indians.) Those living in areas of greatest annual number of fog days and least amount of sunshine showed greatest experience. (Northwestern Indians.)

TABLE V*

IT WAS FOUND:
At 7 years 1 permanent tooth surface per child is affected.
At 9 years 4 permanent tooth surfaces per child are affected.
At 11 years 5 permanent tooth surfaces per child are affected.
At 13 years 9 permanent tooth surfaces per child are affected.
At 15 years 13 permanent tooth surfaces per child are affected.
At 17 years 16 permanent tooth surfaces per child are affected.
At 19 years nearly 25 tooth surfaces per child are affected.

*From tabulation of 6257 school children of Hagerstown, Md., by Klein and Palmer.

Klein and Palmer, in a survey of 6,257 elementary and high school children in Hagerstown, Md., found 4,547 children (or about three-fourths of that total) between the ages of 8 and 15 years, inclusive, with carious teeth requiring fillings, with an average of 2.08 caries per child. They also found in this same age group an average of 1.16 F per child. Had these carious teeth been filled, as perhaps they could have been, we would have an average of 3.24 F per child.

In another survey of 2,627 children in Nicollet County, Minn., between the ages of 8 and 15 years, inclusive, Knutson found an average of 2.14 caries per patient. In the same group of children between 8 and 15 years of age he found an average of 3.04 F per child. Had these carious teeth been filled, as perhaps they could have been, we would have a total average of 5.18 F per patient. By checking patients with x-rays, Hill and Bruckner found approximately three times as many caries plus fillings as have Klein and Palmer ($5.18 \times 3 = 16.4$ F and C).

Thus, we have an average from both groups of the number of fillings for each child who never experienced orthodontic treatment. The 8-year to 15-year interval corresponds to the age bracket in which most orthodontic treatment takes place.

Very little of the foregoing data and information are mine. On the contrary, I am very grateful to Drs. Klein, Knutson, Palmer, Hill, Bruckner, Sloman, and Sharp for practically all data and results of their investigations, and give credit to them for all figures and most statements used in Part I.

The orthodontist possesses very little, if any, dental information regarding his patient before that patient comes under his care. Any firsthand information he may obtain directly would cover only the years the patient was under his treatment or observation.

Therefore, in order to make a fair appraisal of caries experience in orthodontic patients, the foregoing data and information have been brought into the picture to be used as a comparison of those who never experienced orthodontic treatment with those who have been under orthodontic treatment and observation for an average of 4.2 years.

II. INFORMATION OBTAINED ON TEETH OF CHILDREN RECEIVING ORTHODONTIC TREATMENT

The data to be presented represent collected and correlated information rather than the results of a research project, and cover patients over a period of twenty-five years.

Many careless, and certainly thoughtless, statements have been made regarding the detrimental effect of orthodontic treatment upon teeth. This has been especially true regarding teeth which have been banded.

These unfounded statements, together with the possibility of establishing a relation between caries experience and the amount of intake of sugar, fruits, and vegetables, mouth hygiene, and heredity, resulted in one of the forms used for collecting these data. The following information is obtained on this record.

1. Nutritional history is obtained from the mother before treatment is started on the child. Particular note is made indicating which of the three classes of foods she favored mostly in her diet, grading them as (x) very little, (xx) average, and (xxx) excessive.

A similar grading is made regarding fruits and vegetables.

Patients' nutritional history is recorded likewise, plus their care of their teeth.

2. Patients are instructed to have a complete checkup by their dentist a week or so before starting treatment, after which tooth and oral pathology records are taken.

3. For conciseness and avoiding error, teeth are numbered 1 (maxillary right third molar) to 16 (maxillary left third molar) to 17 (mandibular left third molar) to 32 (mandibular right third molar).

4. Surfaces are numbered 1 to 5 (1, mesial; 2, distal; 3, buccal; 4, lingual; and 5, occlusal).

5. All pathology at the beginning of treatment is indicated in red ink. Additional pathology, if any, at the conclusion of treatment is indicated in black ink. Thus, the nature of pathology, if any, occurring during treatment and observation while under our care will be easily noted.

6. Unusual pathology is noted separately.

7. The general quality of the teeth is recorded (A+, excellent; A, average; and A– poor).

8. Gingival condition also is noted and rated as – (normal); x (hypertrophied); and xx (extremely hypertrophied).

The buccal and labial surfaces of patient's teeth are cleaned at each appointment with a powdered dentifrice. Many times the teeth are flossed, and at times scaled, depending upon conditions.

We have found the following condition existing among patients. Some patients take excellent care of their teeth, checked on our chart A+, while others are somewhat careless (A). Still others who disregard constant appeal and warning from parent and orthodontist are recorded as neglectful (A–).

This result of the lack of care is impressed upon the patient and the date of this advice is noted upon our records. Disclosing solution is used on two or three successive occasions to stain food, which we hope will assist the patient in observing food present upon the teeth. It also leaves a mental impression, for children dislike the taste of this solution.

After three "unhygienic visits," parents are notified by letter of the condition. If no definite and continued effort is made by the patient to improve the situation, after the parent has thus been sufficiently notified, the case is dismissed.

We aim, with a powdered dentifrice, to clean thoroughly each tooth which is to be banded, flossing the interproximal surfaces with a wide tape impregnated with flour of pumice, often following up this procedure with alcohol.

The teeth are dried with compressed air before cementing bands. Anterior teeth are completely covered with cement, four to six anterior bands being cemented with one mix. It is the policy, when permanent teeth are banded, to remove and recement them at six- to eight-month intervals, allowing a checkup by the patient's dentist, but principally to allow a check on cementation.

Only three standard brands of cement have been used during the past thirty years: Ames, Fleck, and Stratford-Cookson.

Patients are given definite instructions for oral hygiene. They are given a demonstration upon a Typodent with a junior size brush (preferably a No. 10 nylon bristle brush); this is often followed by an actual demonstration in their mouths.

We try to impress upon them that the only effective cleaning portions of any brush are the ends of the bristles. These must be in contact with the surface to be cleaned. Once the bristles are bent and the long side comes in contact with the teeth, as in usual patient methods of brushing back and forth, the effectiveness of brushing is lost, especially for patients with labial appliances. To conserve space and the reader's time, the detailed method of brushing will be omitted.

The previous statements should acquaint one with the procedure involving cases about to be discussed.

In a great many of these cases when the first pathologic records were taken only the first four molars and eight permanent incisors were present. (As previously stated, all detailed pathology taken at the beginning of treatment is recorded in red. Pathology, if any, occurring during treatment and observation is recorded in black.)

Naturally there is no pathology (red marks) taken on other permanent teeth which erupt during treatment. Should any of these unerupted teeth require banding later in treatment, pathology, if any, is noted and dated at that time.

Often at the time cases are dismissed we find many teeth showing pathology of which we have no previous pathologic record because these teeth had not erupted when the first record was taken. Consequently, this would not be a true picture, as records could not be taken on unerupted teeth. If all permanent teeth were present before and at the conclusion of treatment we would obtain more accurate pathology occurring during the interim.

There are a number of ways all of these records and information may be cross-checked and additional information obtained which will be noted in the following.

Patients Using Excessive Carbohydrate (Twenty-one Patients).—From the collected data, we have been able to obtain much information. For example, we have segregated patients whose mothers partook of excessive sugars and carbohydrates during pregnancy; also patients whose mothers took sparingly of sugars and carbohydrates during that period; likewise, mothers who ate excessively of fresh fruits and vegetables, and vice versa. We have correlated these findings in all four instances.

Then we have correlated the nutrition of individual patients with their own tooth pathology in these four respects, that is, the condition of the teeth of excessive and minimum sugar and carbohydrate eaters when we accepted them as patients, and again at the time of dismissal. Similar comparisons were made of the excessive and mild consumers of fresh fruit and vegetables.

From the 235 cases we have tabulated the relation existing between:

1. Decalcification and caries and excessive carbohydrate intake.
2. Decalcification and caries and minimum carbohydrate intake.
3. Decalcification and caries and excessive fruit and vegetable intake.
4. Decalcification and caries and minimum fruit and vegetable intake.

In order to render this comparison on a percentage level, we have arbitrarily established as a basis, four surfaces of a tooth where decalcification generally takes place, namely, mesial, distal, buccal, and lingual surfaces. Rarely is decalcification found upon the occlusal surfaces or incisal edge.

In each of these cases we have tabulated the percentage of white lines and fillings before treatment, and the per cent of both forms of decalcification at the conclusion of treatment, together with the years intervening, which is an average of 4.2 years.

From the 235 cases there were only twenty-one patients who partook of the excessive amount of carbohydrates and only sixty-nine patients who partook of the minimum carbohydrates.

Decalcified areas are potential caries, and caries preclude fillings.

It is safe to say that one out of ten decalcified areas will eventually be filled within the next 3.5 years. We feel this to be a conservative estimate.

Therefore, if we would take one-tenth of the decalcified areas before treatment (averaging 25.5 per person), we would have 2.5 per cent of the total tooth surfaces (112 surfaces) to be checked off as fewer fillings, namely, 2.5 fillings at the dismissal of the case. This would leave a little less than 1 filling increase per person, which would be a more accurate picture at the end of the 3.6-year average.

Third molar teeth are not considered in any part of this report.

Decalcification is seldom found on any occlusal surface, and therefore only the four vertical surfaces which total 112 (4×28 T) are used in computing the percentage of decalcification.

Five surfaces are taken into account when tabulating the percentage of caries and fillings, making 140 surfaces per patient.

From the concluding exhibits one will observe the following:

EXCESSIVE CARBOHYDRATE CONSUMERS—(twenty-one patients, with an average of 3.6 years of observation and treatment)

BEFORE TREATMENT

1. Decalcified areas ranged from 12 per cent to 49 per cent, or an average of 25.5 per cent per patient.

2. Fillings varied from ten patients with no fillings to one patient with ten fillings, or an average of about 2.25 fillings per patient.

CONCLUSION OF TREATMENT

1. There were four patients who showed no increase of decalcified areas up to one with sixteen decalcified areas increase, or an average of 6 per cent increase. This is not a true increase, as approximately one-half of these decalcified areas are on teeth that had not erupted when the first record was taken. Therefore, there was an actual increase of 3 per cent of decalcified areas.

2. There were four patients with no increase of fillings. There was one with fifteen fillings. (10 per cent of these additional fifteen fillings are on teeth not erupted at the time of the first record.) This patient possessed *no* fillings at the start, but did show 16 per cent of decalcified areas, which, as stated, are potential carious surfaces. There was an average increase of 5 per cent fillings per patient, but, again, this is not a true increase.

There is a total increase of 103 fillings for the twenty-one patients. The total number of fillings for patients (with the greatest increase), possessing nine or more fillings, is fifty-seven. Of these fifty-seven fillings, thirty were on teeth that had not erupted when the first record was taken; or approximately 50 per cent were not actual increased fillings and should not be charged as such. Therefore, taking 50 per cent of the average five filling increase, in

reality we would have only an actual increase of 2.5 fillings per patient. Now let us go a little farther. Conservatively assuming that only one of the decalcified areas before treatment will become carious within the next 3.5 years, we would have at the conclusion of treatment one less filling per patient or 1.5 filling increase per patient (2.5 F – 1 F, or 1.5 F).

There appears to be no definite pattern in the relation of decalcified areas or fillings in the interim between the start and conclusion of those cases which may be noted by comparing detailed records of patients.

Many "increased" fillings, as will be noted here and elsewhere, are the result of (a) pit and fissure conditions (poor union of the enamel), or (b) fillings and decalcified areas in teeth which have erupted after the first records were taken.

MINIMUM CARBOHYDRATE CONSUMERS (sixty-seven patients, with an average of 3.7 years of observation and treatment)

BEFORE TREATMENT

1. Decalcified areas range from 9 per cent to 49 per cent, with an average of 27.1 per cent per patient.

2. Fillings range from thirty-one with no fillings to one with twenty-one fillings, or an average of 2.5 fillings per patient.

CONCLUSION OF TREATMENT

1. There were twenty-three patients who showed no increase in decalcified areas up to three who showed an increase of 20 per cent, and nine patients varying between 10 and 14 per cent. The average increase of decalcified areas was 4.7 per cent per patient, but approximately 50 per cent of these occurred on post erupted teeth. Therefore the actual increase was 2.4 per cent.

2. There were twenty-four patients with no increase in fillings up to one with twenty-three fillings. Eleven of these twenty-three fillings were on teeth not erupted at time of the first record. Seventeen of the total of the twenty-three fillings were occlusal fillings. There were seven other patients ranging from ten to sixteen fillings each. There was an average "increase" of 3.7 fillings per patient. Approximately 50 per cent of the indicated "increased" fillings occurred on teeth which erupted after the first record was taken. Therefore, taking 50 per cent of the average 3.7 fillings increase, there would be in reality only an actual increase of 1.85 fillings per patient at the conclusion of treatment.

Now, again, if we made the same conservative estimate that one of the decalcified areas per patient in the beginning will become carious and filled within the next average of 3.7 years, we would have a further average reduction of one filling, or there would be an actual average of 0.85 filling (1.85 F – 1 F, or 0.85 F) per patient increase in the average of 3.7 years.

COMPARISON OF CARBOHYDRATE CONSUMERS
EXCESSIVE CONSUMERS (21) MINIMUM CONSUMERS (67)

BEFORE TREATMENT

Excessive:		*Minimum:*	
1. Decalcified areas (DA)	average 25%	1. Decalcified areas	27.1%
2. Average F per patient	2.25 F	2. Average "increase" F per patient	2.5 F
3. Average years under treatment	3.6 years	3. Average years under treatment	3.7 years

CONCLUSION OF TREATMENT

Excessive:

1. Additional DA average per patient — 3%
2. Additional F average per patient — 5 F
3. Per cent additional F on teeth *not* erupted at the start of treatment — 50%
   Therefore the present additional F are 50 per cent of the average 5F or — 2.5 F
4. Assuming one DA per patient will become carious and later filled, there would be a further decrease of 1 F average per patient or an *actual increase* per patient of — 1.5 F
   over an av. of — 3.6 years

Minimum:

1. Additional DA average per patient — 2.4%
2. Additional F per patient — 3.7%
3. Per cent additional F on teeth *not* erupted at start of treatment — 50%
   Therefore, the present additional F are 50 per cent of the average 3.7 F or — 1.85 F
4. Assuming that one DA per patient at the start will become carious and filled during the next 3.7 years there would be a further decrease of 1 F per patient at conclusion of treatment or an *actual decrease* of — .85 F
   over an av. of — 3.7 years

Thus, we found that patients consuming excessive carbohydrates at the *beginning* of treatment show about 1.5 per cent less decalcified areas per patient, and 0.25 filling less per patient than found in the minimum consumers before treatment, which is the opposite of general belief.

At the *conclusion* of cases (approximately three and one-half years) the excessive carbohydrate intake patients showed 1.3 per cent increase in decalcified areas per patient over the minimum carbohydrate intake patient, and an increase of three-fifths filling per patient in the excessive over the minimum carbohydrate consumers.

An interesting note: We found two patients consuming an average amount of carbohydrate in which 50 per cent of the four surfaces of the teeth involved decalcified areas. One of these patients showed three fillings on the first record and increased 11 per cent in decalcified areas and three fillings over five years of observation and treatment. The other one possessed no fillings at the start, increased 12 per cent in decalcified areas, and showed no increase in fillings after three years of treatment.

Fruit and Vegetable Consumption.—We have tabulated enamel conditions in correlation with patients consuming an excessive and minimum amount of fruits and vegetables. Out of 235 patients only fifty-two indicated an excessive consumption of fruit and vegetables, while only six were minimum consumers.

The following shows the relation of decalcified areas and fillings at the beginning of the case and the relation of decalcified areas and fillings at the end of a 3.5-year average.

The consumers of excessive F and V before treatment showed:

An average DA of 25.5 per cent per patient, ranging from 11 per cent to 50 per cent, also

An average of 2.3 F per patient, ranging from 1 per cent to 21 F per patient.

At the conclusion of treatment these same patients showed:

Additional DA of 2.78 per cent per patient, and
3.55 additional F per patient.

Approximately 50 per cent of these additional fillings were on teeth not erupted at the start of treatment; therefore, in reality the increase per patient would be 50 per cent of the additional 3.55 fillings, or 1.77 fillings increase per patient.

Assuming that at least one decalcified area per patient before treatment will become carious and filled before the end of four years, this would make one less additional filling at the conclusion of treatment, or an *actual increase* of 0.77 filling per patient.

The minimum consumers of fruit and vegetables before treatment showed:

An average DA of 26.3 per cent per patient, and
An average of 2.3 F per patient.

At the conclusion of treatment these same patients showed:

An average increase of DA of 7.7 per cent per patient, and
An average increase of 3.6 F per patient.

Assuming that at least one decalcified area per patient at the start will become carious and filled before the end of three years, this would make one less additional filling at the conclusion of the case or an *actual increase* of 3.6 fillings per patient.

COMPARISON OF FRUIT AND VEGETABLE CONSUMERS

Excessive (52) Before Treatment		Conclusion	*Minimum* (6) Before Treatment	Conclusion
DA per patient	25½ per cent	5.7 per cent	26.3 per cent	7.7 per cent
F per patient	2.3 F	0.77 F	2.3 F	3.6 F

OBSERVATIONS RELATIVE TO THE INCIDENCE OF DECALCIFICATION

In checking over the pathologic record we have taken of many thousands of teeth, we also find the first permanent molar teeth lead all others in the percentage of decalcified areas. From these records we have yet to find *one* first permanent molar tooth in over 2,000 cases that did not present a decalcified line on the buccal and lingual surfaces upon the first examination. In other words, every first permanent molar tooth exhibited decalcification on both buccal and lingual surfaces, ranging from a faint white line to heavy decalcification involving practically the whole enamel surface. Seldom have we found decalcification on the lingual surface of any tooth necessitating restoration.

Following are the teeth in decreasing order of percentage of decalcified areas:

1. First permanent molar teeth (greatest number of decalcified areas)
2. Maxillary central incisor teeth

3. Maxillary lateral incisor teeth
4. Mandibular incisors
5. Second molar teeth
6, 7. A tossup between cuspids and bicuspids.

We have found lines of decalcification on all second molar teeth, especially the mandibular second molar teeth. These lines traverse the buccal and lingual surfaces diagonally from the distal cusps to the mesiogingival margin. This is attributed to the directional line of the border of the free gingiva during tooth eruption, at which place food has been allowed to remain. Transverse lines generally following the gingival outline are found on many incisors near the incisal third and middle third of the labial surface. We believe they are likewise formed during periods of eruption, due to lack of care at that time and possibly to local acid disintegration similar to those of the second molar teeth just mentioned. Approximately one year or so after the full eruption of permanent teeth the white line decalcification has been found only at the gingiva, and here again we feel it is the result of the disintegrating process of food left in that area.

On permanent teeth which have erupted during treatment and later have been observed for some years, the only white lines which form after full eruption follow the curvature of the gingiva in that area. These lines vary in degree from a faint white line to a heavy white line to a white surface.

The buccal surface of the maxillary second molar teeth hold the record in this respect. Often these surfaces are so decalcified at the time of recording the first pathology that large fillings are necessary before the case is dismissed.

With few exceptions, at the time of the initial pathologic record, we have found either a decalcified area, a white line, or a dark area on the mesial surface of practically all first permanent molar teeth. Perhaps the flattened and broad interproximal contact area due to the width of the second primary molar tooth has something to do with this because of cleansing difficulties.

We aim to recement all bands at six- to eight-month intervals and in spite of this precaution, as well as the recementing of loose bands during treatment, we have recorded a few heavy and faint decalcified lines and areas on buccal and lingual surfaces which were not present before the bands were cemented. We have on record less than twenty-five cavities over this twenty-five-year period which we attributed, together with the above decalcification, to loose bands and areas in which cement had partially dissolved or disintegrated. While the aim is to clean thoroughly the surfaces of teeth to be banded, it is very possible small areas may be skipped, in which case cement would not adhere, predicating future trouble.

Bands are found which apparently are firmly attached to the teeth, but upon removal at the recementing period a portion of the cement is found missing. Strange as it may seem, decalcification was seldom present on these teeth.

Never have we observed any indication of untoward effects of cements upon many thousands of banded teeth, regardless of the length of contact time involved.

We have a pathologic record of all permanent teeth (excluding the four third molar teeth), the length of time each tooth was banded, the number of times each band was removed and recemented, etc. We have recorded decalcifications under headings of white lines (WL), white spots (W sp), white surfaces (W sur), fillings (F), beginning of cavities (b c), and cavities (c), and the surfaces upon which these defects occur—mesial, No. 1 surface; distal, No. 2 surface; buccal, No. 3 surface; lingual, No. 4 surface; and occlusal, No. 5 surface.

Our records show that the teeth which possess the greatest number of white line decalcification are the four first permanent molar teeth, Numbers 3, 14, 19, and 30.

Out of 158 cases, records of which were complete in all details, we have tabulated the following data:

Average time involved per patient, 3.7 years (observation, treatment, and again observation).

149 fillings were recorded before treatment, an average of 2.6 fillings per patient.

680 new fillings were recorded after treatment, an average of 4.1 fillings per patient.

Actually the fillings per patient are 2.75 fillings as explained later in this article.

26.4 per cent of the four surfaces (Nos. 1, 2, 3, and 4) of all permanent teeth present showed decalcification before treatment.

There was a 5 per cent increase of decalcified areas on the four surfaces during the 3.7 years.

Extremes are noted in the number of fillings recorded at the beginning and conclusion of the cases.

At least one-third of these new fillings were replacements of decalcified areas charted at the beginning of treatment on the mesial surface of the four first permanent molar teeth and interproximal surfaces of incisors. This would reduce the actual fillings to 2.75 fillings per patient. One-third were the result of poor union of the enamel at fissures and sulci, and on teeth not erupted when the first pathologic record was taken.

There appears to be no definite trend in the correlation between the maximum fruit and vegetable intake patients or the minimum fruit and vegetable intake patients and incidence of caries.

During this twenty-five-year period we have found many teeth without visible defects at any time during our care. There was an increase of approximately 1 per cent of decalcification on these buccal and lingual surfaces at the time of dismissal of the patients. The total time of treatment and observation averaged 4.2 years.

The recording of all enamel defects, fillings, etc., of the permanent teeth of all patients before and after treatment, and correlating these findings from various angles with the carbohydrate, fruit, and vegetable intake of each patient has turned out to be an endless and tedious task.

To help simplify gathering, compilation, and the comparing of data, each erupted permanent tooth is numbered and represented by a rectangular figure. Chart 1 represents the accumulated data of one such erupted permanent tooth of the 235 patients.

SURFACE

PATHOLOGY	#1		#2		#3		#4		#5			
C	1	1	1	0	3	0	0	0	3	2	8	3
WL	18	7	18	0	235	0	235	2	0	0	506	9
WSP	50	24	7	6	3	2	3	2	0	2	63	36
F	15	2	4	1	0	0	18	2	68	63	105	68
BC	6	7	1	1	0	0	0	0	11	1	18	9
W SUR	12	4	0	4	0	0	0	0	1	0	13	
	102	45	31	12	241	2	256	6	83	68		8

Chart 1.—Surfaces of No. 3 tooth (maxillary right first molar).

Each "tooth" is divided into five vertical columns representing the five surfaces of each tooth; and also into six horizontal rows, one for each classification of recorded pathology, at both the beginning and dismissal of the case. Thus from each "rectangular tooth" chart we can see at a glance the total pathology of the same tooth of all patients when the cases were accepted and dismissed. It also provided us with the type of pathology present, on which teeth and where, as well as the teeth which were more resistant or immune to destructive forces while the patient was under our care.

There are two rows of figures in each column. The numbers in the left row indicate the total pathologic conditions present on each surface when the first record was taken. The numbers in the right column indicate the additional pathology, if any, taking place during treatment.

The figures on the outside of each "tooth" represent the total pathology at the start and total pathology at dismissal of all the 235 cases.

The figures on the left side of the "tooth" indicate the totals of the six classified enamel defects present on that same tooth of all patients at the start of the case. The figures on the right side of the "tooth" indicate the totals of the six classified enamel defects on that same tooth of all patients at the conclusion of treatment.

The outside bottom figures give the total number of defects accumulated on each of the five surfaces.

TOTAL DECALCIFICATION

Incidence of CARIES (C) in decreasing sequence

Before Treatment			Conclusion of treatment	
Tooth No.	Total (c) at start	Additional (c) at finish	Tooth No.	Decreasing order of additional caries
30	18	5	30	5
14	9	1	2	3
3	8	3	3	3
9	7	0	4	3
2	4	3	5	2
4	4	3	15	2
5	3	2	29	2
15	3	2	31	2
24	3	1	10	1
26	3	1	14	1
7	2	0	23	1
12	2	0	24	1
31	2	2	25	1
10	1	1	26	1
11	1	0		
21	1	0		
23	0	1		
25	0	1		
29	0	2		
All remaining teeth negative.				

Chart 2.

TOTAL DECALCIFICATION

Incidence of WHITE LINES (WL) in decreasing sequence

Before Treatment			Conclusion of Treatment Av. 4.2 years	
Tooth No.	Total (WL) start	Additional (WL) finish	Tooth No.	Decreasing order of (WL) additional
3	506	9	31	75
14	500	5	15	50
30	485	0	2	41
19	472	17	27	26
8	108	0	11	24
2	86	41	6	20
9	81	1	20	20
7	78	11	5	19
10	76	6	29	19
31	72	75	13	18
13	46	18	12	17
15	43	50	19	17
21	41	8	28	16
5	41	20	18	15
6	40	19	4	11
23	40	6	7	11
25	40	6	3	9
28	40	16	21	8
4	39	11	24	8
24	39	8	26	8
26	39	8	22	7
27	39	26	10	6
12	35	17	23	6
18	32	15	25	6
22	29	24	14	5
11	24	19	9	1
29	23	7	8	0
20	16	20	30	0

Chart 3.

Here again it is possible to see at a glance the surfaces which are affected the most and by which type of defect.

Also, it can be readily seen which of the six pathologic conditions predominate in each tooth of all cases.

As one might expect to find, the surfaces of many teeth are negative, while some show a consistent positive record.

TOTAL DECALCIFICATION

Incidence of WHITE SPOTS (WSP) in decreasing sequence

Before Treatment			Conclusion of Treatment Av. 4.2 years	
Tooth No.	Total (WSP) start	Total (WSP) finish	Tooth No.	Decreasing order of additional (WSP)
8	95	8	3	36
3	63	36	4	27
14	46	18	2	24
9	42	14	10	21
7	41	14	14	18
30	38	10	29	15
10	33	21	9	14
2	12	24	30	10
4	10	27	15	9
13	9	5	5	8
5	7	8	8	8
6	6	3	12	8
11	5	5	11	5
21	4	1	13	5
25	4	1	22	4
15	3	9	24	4
22	3	4	26	4
27	3	3	6	3
12	2	8	27	3
20	2	2	31	3
24	2	4	20	2
26	2	4	28	2
28	2	2	21	1
31	2	3	25	1
29	1	15	23	0
23	1	0	18	1
18	0	1	19	1
19	0	1	23	0

Chart 4.

We have tabulated some 2,000 cases (in which more than 8,000 first molar teeth, 1,500 second molar teeth, and 1,600 incisors are involved). They follow the same pattern as the 235 cases in which we find in *decreasing order* the six recorded pathologic divisions (Charts 2-7): (1) caries, (2) white line decalcification, (3) white spot decalcification, (4) fillings, (5) beginning caries, and (6) white surface decalcification.

TOTAL FILLINGS

Incidence of FILLINGS (F) in decreasing sequence

Before Treatment			Conclusion of Treatment Average 4.2 years	
Tooth No.	Total (F) at start	Total (F) at finish	Tooth No.	Decreasing order of additional (F)
19	122	94	19	94
3	105	68	30	79
14	98	57	2	69
30	93	79	3	67
15	27	51	14	57
2	24	70	15	51
31	20	42	31	42
13	14	38	13	38
18	13	26	29	34
12	12	21	18	26
5	8	19	12	21
7	7	11	5	19
10	6	6	7	11
29	5	34	9	8
8	4	3	11	8
9	4	8	10	6
24	0	1	23	4
25	2	3	8	3
11	1	8	25	3
21	1	2	26	3
22	1	1	21	2
23	3	1	22	1
26	0	3	24	1
4	0	0	4	0
6	0	0	6	0
20	0	0	20	0
27	0	0	27	0
28	0	0	28	0

Chart 5.

TOTAL DECALCIFICATION

Incidence of BEGINNING CARIES (BC) in decreasing sequence.

Before Treatment			Conclusion of Treatment Average 4.2 years	
Tooth No.	Total (BC) at start	Total (BC) at finish	Tooth No.	Decreasing order of additional (BC)
30	21	4	3	9
3	18	9	14	6
14	12	6	15	5
2	11	3	21	4
8	5	1	30	4
10	5	1	2	3
7	4	1	13	3
5	3	0	31	2
9	2	1	7	1
13	2	3	8	1
31	2	2	9	1
18	1	0	10	1
24	1	0	11	1
26	1	0	12	1
15	0	5	19	1
21	0	4	4	0
11	0	1	5	0
12	0	1	6	0
19	0	1	18	0
4	0	0	20	0
6	0	0	22	0
20	0	0	23	0
22	0	0	24	0
23	0	0	25	0
25	0	0	26	0
27	0	0	27	0
28	0	0	28	0
29	0	0	29	0

Chart 6.

TOTAL DECALCIFICATION

Incidence of WHITE SURFACES (W sur) in decreasing sequence

Before Treatment			Conclusion of Treatment Average 4.2 years	
Tooth No.	Total (W sur) at start	Total (W sur) at finish	Tooth No.	Decreasing order of white surfaces
14	44	6	2	31
2	29	31	15	29
10	27	6	21	15
7	22	7	12	9
8	20	2	3	8
9	17	3	7	7
15	16	29	11	7
22	16	1	5	6
13	14	3	10	6
3	13	8	14	6
25	13	0	28	6
21	10	1	30	6
12	10	9	31	6
5	8	6	6	5
26	8	1	27	4
30	8	6	29	4
24	7	1	9	3
4	4	15	13	3
6	4	5	20	3
20	4	3	8	2
27	4	4	19	2
11	3	7	21	1
18	2	0	22	1
28	2	6	24	1
29	2	4	26	1
31	2	2	18	0
23	1	0	23	0
19	0	2	25	0

Chart 7.

LIST OF TOTAL DEFECTS AND FILLINGS IN DECREASING SEQUENCE*

Before Treatment			After 4.2-Year Average	
Surface	Defects and Fillings		Surface	Defects and Fillings
3	2010		5	472
4	1214		3	450
1	546		1	266
5	409		4	203
2	294		2	129
Total	4473		Total	1520
Average defects and filling per patient:		21%	Average defects and fillings per patient:	7%

Chart 8.—Total number and type of defect on each erupted permanent tooth, before and at conclusion of treatment of 235 patients.

*There are approximately one-third additional total defects over 4.2-year average.

These defects are divided into the following groups:

Beginning

C, 60—1 C for every fourth patient
WL, 3090—13 WL for every patient
WSP, 413—1.7 WSP for every patient
F, 570—2.4 F for every patient
BC, 55—1 BC for every fourth patient
W sur, 285—1.2 W sur to every patient
Total 4473

Finish

C, 18—1 C to each thirteenth patient
WL, 445—1.5 WL to each patient
WSP, 241—1 W SP to each patient
F, 621—2.6 F to each patient (actual 1.7 F per patient explained below)
BC, 36—1 BC to about each seventh patient
W sur, 159—1.5 W sur to each patient
Total 1520

In order to have a fair picture of the increase in fillings, the potential source of fillings before treatment should be reviewed. Caries and incipient caries at the start definitely mean fillings at a later time, and these total 116. If we deduct these from the 621 fillings at the finish of the cases we would have 505 fillings, or an equivalent of 1.7 fillings per patient increase over 4.2 years instead of 2.6 fillings per patient. The areas marked "white spots" are definite potential cavities requiring fillings later. At least 90 per cent of these are found on the interproximal surfaces of the eight incisor and four first molar teeth. Our records show a decided increase of fillings on these and occlusal surfaces of all molar teeth.

TOTAL DEFECTS ON ALL 5 SURFACES LISTED IN DECREASING SEQUENCE

Before Treatment		Conclusion of Treatment	
Tooth No.	Defects	Tooth No.	Defects
3	713	2	172
14	709	15	147
30	663	3	133
19	474	31	126
8	232	30	104
2	169	14	93
9	161	29	74
7	154	13	67
10	145	4	57
31	100	12	56
15	92	5	55
13	87	7	45
5	70	11	45
12	61	18	42
25	60	10	41
4	57	9	40
21	57	27	33
26	53	19	31
24	52	20	26
6	50	28	24
22	49	6	17
18	48	26	17
27	46	21	16
28	44	24	15
23	42	8	14
11	34	22	13
29	29	25	9
20	22	23	8
Total	4473	Total	1520
Average per patient 19% or 11% less than found in children who received no orthodontic treatment		Average per patient 6.5%	

Chart 9.

SUMMARY (PART I)

Children receiving no orthodontic treatment:

1. Total permanent teeth present in this survey	79,688
2. The per cent of total surfaces involved	31 per cent
3. The per cent of 15-year-old children with one or more carious teeth	95 per cent
4. An average of eighteen permanent teeth per child—carious surfaces per child	5.5 per cent
5. The greater per cent of total caries are found in the four first molar teeth, mandibular second molar teeth, and the four maxillary incisors equalling	91 per cent
6. Of the total caries in the maxilla, the greater per cent are found in first molars	64 per cent

7. Of the total caries in the mandible, the greater per cent are found in first molars — 87 per cent
8. The four canines are least affected
9. The per cent of total defects occurring on the occlusal surface — 43 per cent
10. The per cent of total defects occurring on the mesial and distal surfaces — 31 per cent
11. The per cent of total defects occurring on the buccal and lingual surfaces — 26 per cent
12. Fillings from various surveys ranged from 3.24 to 16.4 (F+ caries) per child, averaging — 4.11 F
13. Average caries per child — 2.7 C

COMPARISON OF DEFECTS

PART I		PART II			
		BEFORE TREATMENT		CONCLUSION OF TREATMENT	
SURFACES	PER CENT OF TOTAL DEFECTS	SURFACES	PER CENT OF TOTAL DEFECTS	SURFACES	PER CENT OF TOTAL DEFECTS
Occlusal	42.8	Buccal	45	Occlusal	31
Mesial	17.4	Lingual	27	Buccal	29
Distal	14.3	Mesial	12	Mesial	17.5
Buccal	13	Occlusal	9	Lingual	14
Lingual	12.4	Distal	7	Distal	8.5
Approximately one-half of the total fillings are on the occlusal surface.		There are approximately two times more defects on the buccal surface than on any other surfaces.		Defects on the occlusal surface equal about one-third the sum of all surface defects.	

SUMMARY (PART II)

Total permanent teeth observed	4,468
Total permanent teeth present before treatment	3,465
Total defects present before treatment	4,478
Average defects per tooth	$1\frac{1}{3}$
Total additional permanent teeth present at conclusion of treatment	1,003
Total additional defects present at conclusion of treatment	1,520
Average additional defects present at conclusion of treatment	1.5
Approximately 50 per cent of the defects present at the conclusion of treatment are on teeth which erupted after the first record was taken. Therefore the *actual increased* defects per tooth are	0.75
Total tooth surfaces observed before treatment	17,325
Per cent of tooth surfaces involved before treatment	25.75 per cent
Total additional tooth surfaces observed at conclusion of treatment	5,015
Per cent of additional tooth surfaces involved at conclusion of treatment	3 per cent
As stated previously, one-half of the "additional" defects (or surfaces) occur on posterupted teeth; therefore, the *actual increase* would be	1.5 per cent
Average fillings increase per child at conclusion of treatment	1.7

LOCATION OF FILLINGS

BEFORE TREATMENT		CONCLUSION OF TREATMENT	
SURFACE	PER CENT OF TOTAL FILLINGS	SURFACE	PER CENT OF TOTAL ADDITIONAL FILLINGS
Occlusal	75.5	Occlusal	74.5
Mesial	8.5	Mesial	7.6
Distal	7	Distal	7.6
Lingual	6	Lingual	7.5
Buccal	3	Buccal	2.8

There are approximately three times more fillings on the occlusal surface than on the other four surfaces combined, both before and at the conclusion of treatment.

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VARIABILITY AND AGE CHANGES IN OVERJET AND OVERBITE

Report From a Follow-up Study of Individuals From 12 to 20 Years of Age

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THE development of the bite is characterized by continued changes in its structure and in the position of the teeth during the growth of the individual up to adult age. Changes take place in the position of the single teeth, in the shape and size of the dental arches, and in their mutual relation, i.e., in the occlusion of the teeth.

Such age changes in the bite of the growing individual have been observed and described in serial investigations in which the individual development has been followed by means of dental casts,[1, 11, 17, 19, 20, 24] or in series of radiographs.[4, 6, 7]

Apparently, changes in the bite also occur to some extent in adults, and are supposed to be due chiefly to changes in the position of the individual teeth.[2]

The changes in the structure of the bite observed in this manner during the actual period of growth of the individual can be attributed to the growth and development of the dentition and of the facial skeleton and the cranial base. The functional conditions thereby play a formative or modifying role in the formation of the structure of the bite; this is due to the functional properties of the face in mastication, respiration, and speech, and also to its mimic function.

The total effect of these factors, depending upon an interrelationship between various exo- and endogenous influences, brings about changes in the structure of the bite which can be measured and, therefore, also can be made the subject of correlative studies.

The purpose of the present article is to deal with a limited number of these problems to the extent permitted by the methods used.

MATERIAL AND METHODS

The material of this study comprises two series of cephalometric x-ray films taken in a group of Swedish boys who were first examined at the age of 12 years, and then re-examined at the age of 20.

From the beginning, the group of 12-year-old boys comprised 322 who had been chosen at random for the purpose of serving as a representative group of the Swedish population at that age.

The variability in the position of the teeth and the facial structure in the original group of 12-year-old boys has been subjected previously to a statistical analysis in comparison with the variability in a similar group of 281 adult

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males, aged 21 to 22 years (Björk, 1947). The follow-up study that has been undertaken now by requesting the original 12-year-old group to appear for renewed examination at the age of 20 comprises 243 individuals in all.

Three series of radiographic measurements of the bite and the facial skeleton now have been prepared from this follow-up study and are available for analysis. These three series comprise partly the values of the various determinations of measurements when the subjects were 12 years old and corresponding measurements when they were 20, and the series of differences which have been ascertained between the two age levels.

The mean value of the calculations in the 12-year series (M_{12}), the same calculations in the group of 20-year-old individuals (M_{20}), and the standard deviation of the different values measured (s_{12} and s_{20}, respectively) now afford information about the variability of the various properties at the two age levels.

The differences also could be analyzed statistically in the same manner as the primary values in the different age groups. A calculation of the mean value of these differences (M_D) shows the average change of each property that has been calculated, i.e., the general trend of the development.

As the differences in each property could be calculated for the single individual, it is possible also to calculate the individual inequality of the development; this can be expressed as the standard deviation of the differences (s_D) around their mean values.

It then is possible by means of correlative calculations to study the covariation of the various age changes during the development, i.e., the correlation between series of differences. An analysis of this nature will show to what extent the growth changes in the development of the structure of the bite and the shape and size of the facial skeleton are dependent upon each other, or whether they occur independently in the course of the development of the individual.

Furthermore, it is possible to correlate the primary values found in the 12-year group with the age changes of the same properties, i.e., with the calculated growth differences, and thus to get an idea of the question whether or not primarily different types show a different development. For instance, it can be determined whether the development in the various types of malocclusion is different, and whether markedly prognathous faces show another and different growth pattern than faces of a retrognathous, i.e., less prognathous type, etc.

The radiographic method used, as well as the method of measurement and a calculation of its reliability, has been described in a previous publication.[3]

The radiographic method is based upon the principles described by Broadbent (1931). The distance from the focus of the x-ray tube to the median plane of the head corresponds to the one used by Broadbent (155 cm.). The distance between the film and the median plane of the head, which in Broadbent's technique varies according to the width of the head, has, however, been con-

stant (9 cm.) with the technique used here. In order to get a clearer picture of the soft parts of the profile, a wedge-shaped aluminum filter was placed between the object and the film in the type of cephalostat, or head holder, used at the re-examination (Fig. 1). It will also be noted from this figure that the head is in free balance and thus not oriented to FH. This head holder is an improvement of the one used at the first examination, and also has been constructed to be used as a portable cephalostat in field work.

Fig. 1.—Head holder, or cephalostat, for x-ray photography. The photograph illustrates the use of the head holder when taking lateral exposures of the head. A wedge-shaped aluminum filter has been inserted between the subject and the film in order to make the soft profile visible.

The part of this growth study which is to be dealt with in the present article is limited to age changes in the occlusion of the teeth in the sagittal and vertical planes. The growth of the facial skeleton, and thus also of the bite, is correlated in all three planes. As the re-examination also comprised roentgenograms of the head with the teeth in occlusion, as well as with the mandible in the rest position, dental casts, photographs, and head measurements, these problems will be discussed in greater detail in subsequent publications.

VARIATION

An analysis of the variability of the single components of the bite, such as the sagittal and vertical relations of the dental arches, and the age changes of these components within a population sample, can be undertaken only if the properties studied can be metrically determined.

Theoretically, the variability of the sagittal relation, or occlusion, of the dental arches can be estimated from any point within the arches. For practical reasons this relation is usually expressed as molar occlusion or as incisal occlusion, determined as the horizontal overbite or overjet.[3, 12, 18] In both cases the

relation found expresses both the sagittal interrelationship between the two dental arches and local displacements of the teeth. The molar position thus changes consequentially to loss of teeth. Similarly, the position of the front teeth also can be influenced by loss of teeth and by pressure exerted by the fingers, the tongue, the lips, etc.

This article will be limited to the discussion of the incisal occlusion. An analysis of its relation to molar position and to the degree of spacing of the teeth in the dental arches will be presented in a subsequent article.

The overjet, as well as the molar position, may serve as a measure of the variation in the sagittal occlusion; to this also should be added the fact that it is easier to determine more exactly the position of the front teeth metrically. From a functional point of view the deviation in the occlusion of the front teeth is of greater importance than a determination of an anomalous position of the molars, which does not necessarily require adjustment if the bite is otherwise functionally well balanced.

The vertical occlusion as well can be determined by the position of the front teeth, expressed as the degree of vertical overbite. The normal variation in the vertical occlusion of the jaws can be characterized primarily as the different degree of vertical compression of the jaws, as the face in cases of deep vertical overbite of the front teeth is characterized by a reduced morphologic height from the nasion to the gnathion when the jaws are closed.[3, 15, 18, 21]

To this picture may be added the supra- or infraposition which may occur with one or several of the front teeth in the form of local displacements of these in a vertical direction.

The elongation of the front teeth in deep bite in reality seems to be apparent largely because the lateral sections of the alveolar arches, or the jaws or face, are vertically underdeveloped.

This also appears from the concept created by Brodie and Thompson, "the rest facial height," by which is understood the facial height when the mandible is in the rest position.[21] According to these authors, this height is more stable and more representative of the vertical facial height than the morphologic one. Clinically this concept is of value in estimating a dysplastic development of the face in the vertical direction, in case of both hypoplastic[10] and hyperplastic development.[9]

In our calculations from 1947 a significant negative correlation between overbite on one hand and the morphologic facial height on the other was proved to exist.[3] The coefficient of correlation was calculated to –0.27 in the series of 12-year-old subjects, and to –0.36 in the adult group.

In the present re-examination of 20-year-old subjects, the size of the freeway space, or the interocclusal clearance, shows a significant positive correlation with the degree of overbite, as expected. The coefficient of correlation has been calculated to 0.45.

Since at present we want only to find an expression for the variation in the occlusion of the front teeth in sagittal and vertical direction, we shall confine

our study to the variability and age changes in overjet and overbite of the front teeth. The technique of measuring overjet and overbite in x-ray pictures is shown in Fig. 3.

It appears from Table II that the variability is somewhat greater in overjet than in overbite. It may be of some interest to state the range in addition to the calculated standard deviation of these properties. The range of variation and the extreme values in the group of 12-year-old subjects, followed to their twentieth year, appear from the following figures in millimeters:

	12 years	*20 years*
Overjet	17.3 (–4.7/12.6)	18.0 (–5.2/12.8)
Overbite	13.6 (–2.0/11.6)	13.0 (–4.8/ 8.2)

As previously has been shown statistically, this great range of variation generally is due mainly to the deviation in the facial skeleton and the base of the skull, and, on an average, only to a lesser extent dependent upon the deviation localized to the dentition. In individuals, however, local factors are undoubtedly of very great importance, as will be discussed later.

COVARIATION

In the method of analysis described here a primary division of the occlusal pattern may be made in what we have termed the variation of the first order. This comprises an estimate of the development of the bite or of the occlusion in three planes. The variability in the sagittal and vertical planes thus can be expressed as the incisal occlusion (Table I). The variability in the transverse direction is more complicated, however, and will be dealt with in a special study.

Table I. Classification of the Occlusal Pattern According to Overjet and Overbite Values

	VARIABLE	a	b	c
1	Sagittal occlusion: overjet	a_1 mandibular overjet <0 mm.	b_1 normal maxillary overjet 0 – 6 mm.	c_1 extreme maxillary overjet $\geqslant 7$ mm.
2	Vertical occlusion: overbite	a_2 open-bite <0 mm.	b_2 normal overbite 0 – 4 mm.	c_2 deep-bite $\geqslant 5$ mm.

A division of the incisal occlusion according to the simultaneous variation in overjet and overbite is of great clinical importance.

The overjet and overbite are correlated, but this relationship cannot be expressed in the form of a straight line. We have previously expressed the average covariation so that, starting from edge-to-edge bite, the overbite increases when the overjet increases in a positive direction. The depth of the bite thus is generally larger when the maxillary overjet is large. In addition, the overbite also shows an average increase when the overjet decreases, starting from edge-to-edge bite, i.e., in mandibular overjet cases. This is illustrated by the dashed line in Fig. 2, *a*, calculated from the re-examined part of the 12-year-old group.

Following the procedure used in Table I, we divide the distribution into three groups, with the most normal values in the center.

For each variable we thus have a center group, termed the normal group, and two extreme groups.

To determine approximately the range of the center groups, the histogram of the distributions was studied, and the borders were transferred as the values given in Table I (approximately within the limits of $\pm$ 1.5 s). As previously shown (Björk, 1947), the distributions of overjet and overbite both show a marked positive excess, and thus do not follow a normal distribution curve. About 90 per cent of the distributions then will fall within the center groups, as shown in Tables III and IV. This grouping is arbitrary, but corresponds quite well to clinical experience.

We have, then, two properties of the bite, each expressed in a three-grade scale. It is now also of importance to get an expression of how they are combined in the single individual. According to the diagram in Fig. 2, *a*, we then have 3^2, or 9, possibilities of combination.

a_1a_2	b_1a_2	c_1a_2
a_1b_2	b_1b_2	c_1b_2
a_1c_2	b_1c_2	c_1c_2

The incisal occlusion characteristic of each of these groups of combinations will appear as in the diagram in Fig. 2, *b*.

The distribution in per cent of these group combinations at 12 and 20 years is shown in Table V.

Now, if the variation of the occlusion of the dental arches in the transverse direction also is calculated in addition to the two variables mentioned, an occlusal analysis of the first order gives 3^3, or 27, possibilities of combination.

Each of these three variables then can be divided again into a number of different factors, which is termed variation of the second order. By dividing these into additional subdivisions we get the variation of the third order. This method will be explained in greater detail in subsequent publications.

This form of orthodontic, or bite, analysis has been termed the combination method of analysis. According to its nature it is purely morphologic.

Although an important factor in orthodontic diagnosis, a morphologic analysis alone is not a sufficient basis for an estimate of the indication for treatment. A more complete form of bite analysis, of course, should also comprise a functional analysis[14, 16, 22, 23, 26] and, in growing individuals, a growth analysis, where this can be made.[4]

AGE CHANGES

Malocclusions are to be considered largely as symptoms of a dysplastic facial development. Changes in the structure of the bite with advancing age also may be considered largely as symptomatic and indicative of a change in the proportion between the various parts of the facial skeleton and the base of the skull. To what degree and in what manner such age changes in the bite are dependent upon facial growth and development will be dealt with in subsequent publications.

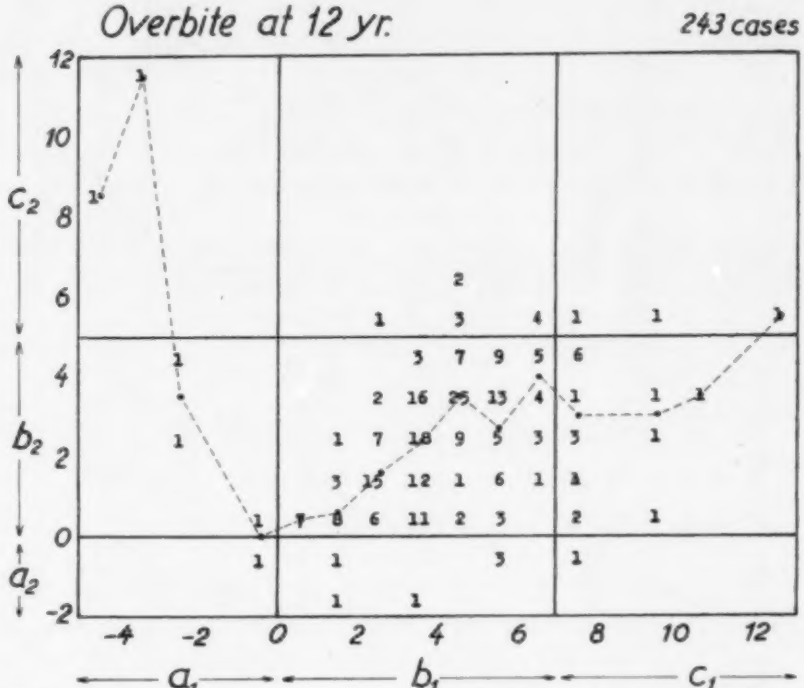


Fig. 2a Overjet at 12 yr.

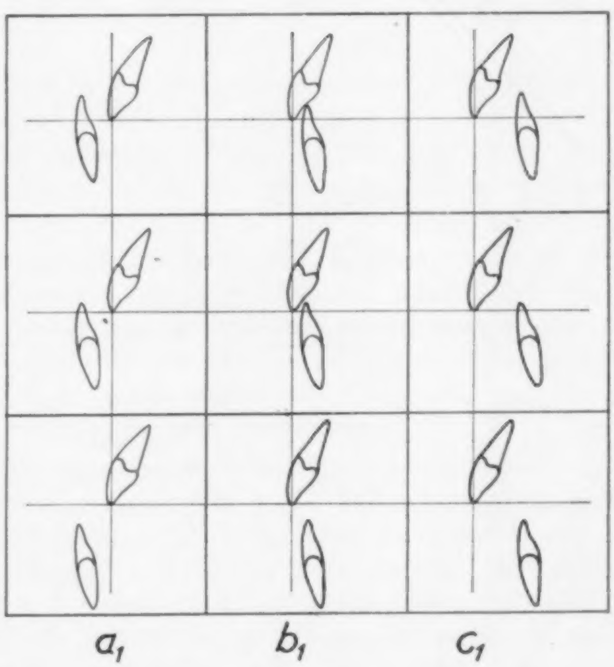


Fig. 2b a_1 b_1 c_1

Fig. 2.—*a*, The relation between the values in overjet and overbite at the 12-year age level. The dashed line connects the mean values in overbite for each millimeter class of overjet. *b*, Diagram showing the mutual position of the front teeth of the upper and lower jaws when grouped according to the combination method of analysis of the first order.

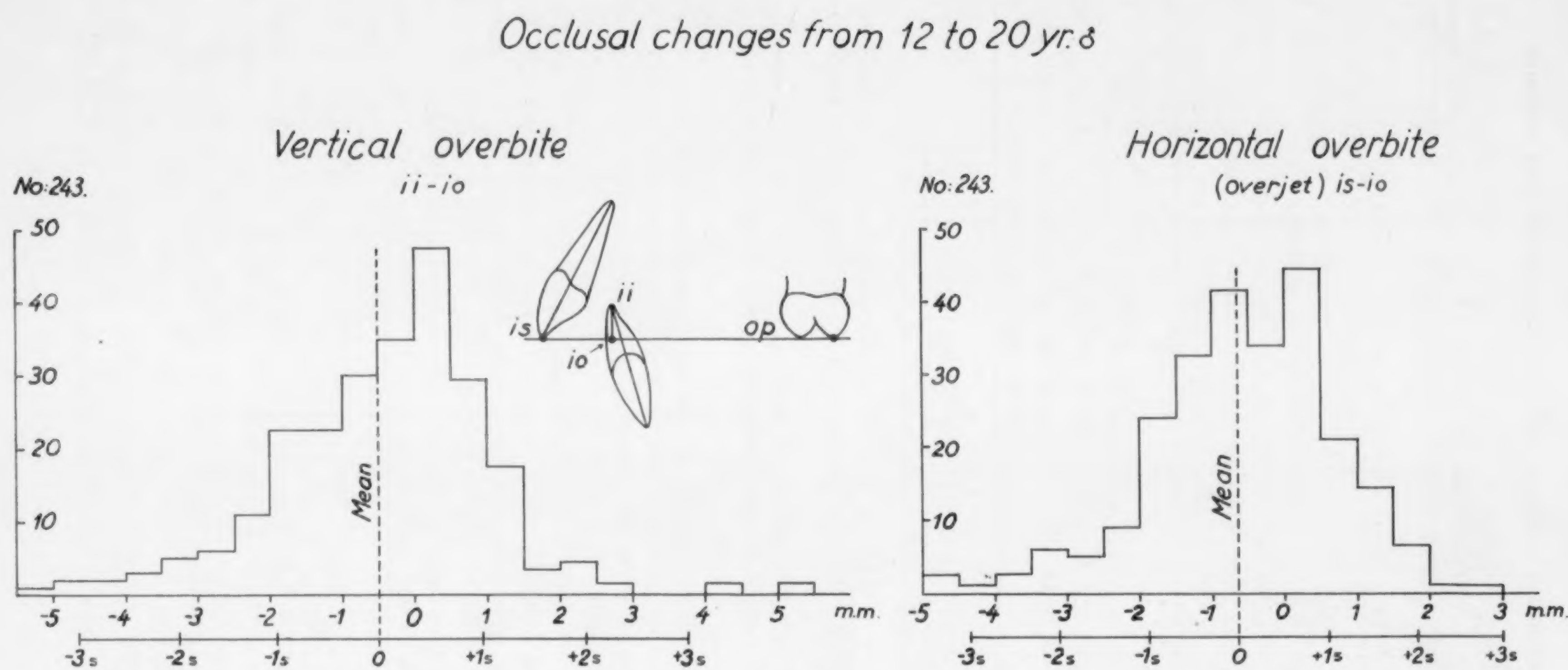


Fig. 3.—The overjet and the overbite generally show a decrease with advancing age. Individually, however, age changes occur in both directions to an extent appearing from the distribution shown in the figure. The figure also shows the method of measuring the overjet and the overbite from a cephalometric x-ray photo.

The present article will be confined to a discussion of the extent and direction of the age changes in overjet and overbite, and the covariation of these age changes.

The arithmetical mean and the standard deviation for overjet and overbite in the 12-year-old group, and for the same individuals at the re-examination at 20 years (243 cases), are shown in Table II. The table also shows the mean

TABLE II. THE MEAN VALUES FOR OVERJET AND OVERBITE AT 12 YEARS (M_{12}) AND FOR THE SAME INDIVIDUALS, 243 CASES, AT 20 YEARS (M_{20}), THE MEAN VALUES OF THE AGE DIFFERENCES (M_D), AND THE STANDARD DEVIATIONS (s) FOR THESE DETERMINATIONS, IN MILLIMETERS*

VARIABLE	$M_{12} \pm \epsilon(M)$	s_{12}	$M_{20} \pm \epsilon(M)$	s_{20}	$M_D \pm \epsilon(M)$	s_D	s_D/s_{12}	ERROR OF MEASUREMENT
overjet (is-io)	4.1 ± 0.14	2.2	3.4 ± 0.15	2.3	–0.7 ± 0.08	1.2	0.55	0.27
overbite (ii-io)	2.6 ± 0.11	1.8	2.1 ± 0.12	1.9	–0.5 ± 0.09	1.4	0.78	0.31

*The Errors of Measurement Are Calculated From Double Determinations.

value of the age difference (M_D) and its standard deviation (s_D). Furthermore, the table gives the quotient between the standard deviation for this age difference and the standard deviation at 12 years (s_D/s_{12}).

As the age changes measured also should be considered in relation to the error of measurement, i.e., to the reliability of the method of measuring, these errors also have been given in the table. These refer to the values of the error of measurement stated in a previous publication, calculated by double determinations.

As was shown also by our previous cross-sectional studies, both overjet and overbite show a reduction during the developmental period from 12 to 20 years of age. However, of special interest here is the great individual dissimilarity appearing, which is expressed by the standard deviation of these age changes (s_D).

The order of magnitude of the changes in these properties of the bite with advancing age also appears from the calculated quotient between the standard deviation of the difference and the standard deviation at 12 years (s_D/s_{12}). It appears from these quotients that the change in overjet amounts to 55 per cent of the primary variation, and in overbite to 78 per cent, the latter thus showing a greater variability with age than the former.

In some cases the changes are indicative of a great reduction, whereas in other cases the values increase with age. The average change thus becomes comparatively small in relation to the range of the age changes. The range of variation for age changes in overjet is 7.4 mm., the most extreme reduction being –4.8 mm., and the most extreme increase being 2.6 mm. (Fig. 3). A reduced value in overjet indicates a more forward position of the lower dental arch in relation to the upper dental arch.

In overbite the range of variation of the age change is still greater, and amounts to 10.1 mm. The most extreme bite opening amounts to –5.1 mm., and

the similar extreme value for increasing depth of bite to 5.0 mm. as shown in Fig. 3.

If we now correlate the age change in overjet and overbite, as shown in the diagram in Fig. 4, *a*, we will find that changes take place to a varying degree in the great majority of cases. The number of cases in which overjet and overbite remain unchanged from 12 to 20 years, within the limit ± 1 mm., thus is not greater than 93, which corresponds to 38 per cent of the sample.

We shall find also that the age changes in overbite occur in both directions, as well at increased as at decreased value of the overjet.

This incisal displacement of occlusion does not occur quite independently in sagittal and vertical direction, which appears from the distribution in Fig. 4, *a*. The dashed line, which connects the mean values of the age changes in overbite for each millimeter change in overjet, shows a curved relationship, which corresponds to the one illustrated in Fig. 2, *a*, where the primary values in overjet and overbite were correlated.

The depth of the bite, in other words, is generally increasing at a displacement forward as well as backward of the incisors of the lower jaw in relation to those of the upper jaw, but with a great individual dispersion in both directions.

A question of perhaps greater interest is how these age changes are connected with different primary types of occlusion.

The general trend of the development in the sagittal occlusion of the incisors is toward a more forward position of the lower dental arch in relation to the upper dental arch.

If the age changes in overjet are correlated with the degree of overjet at the age of 12 (Fig. 4, *b*), we shall find that this general trend of a relative displacement forward of the dental arch of the lower jaw occurs in all three groups of overjet, mandibular (a_1), normal (b_1), and extreme maxillary (c_1). The mean decrease in overjet is –2.0 mm., –0.7 mm., and –1.5 mm. in the three groups, and thus is greatest in the two extreme groups. These values differ significantly. A relationship between the degree of age change in overjet and the degree of overjet at 12 years, i.e., the primary type of occlusion, seems to be present. The coefficient of correlation is –0.21, which value is significant. The linear regression is illustrated in Fig. 4, *b*. It is apparent, however, that the values in group (a_1) all are situated beneath the regression line. In order to examine whether the distribution is of a nonlinear type, as the mean value in the three groups indicates, we have calculated a parabolical regression and found that such a relationship also is significant. This may be explained as an influence of group (a_1) to a curved regression.

The forward displacement of the mandibular incisors in relation to the maxillary ones, which usually occurs with age, will be greater the bigger the maxillary overjet is at the age of 12. This means in effect that the overjet diminishes more with age in the case of extreme maxillary overjet than when the bite has a normal degree of overjet. This may be ascribed to the functional conditions, and not to a different growth pattern of the jaws in these

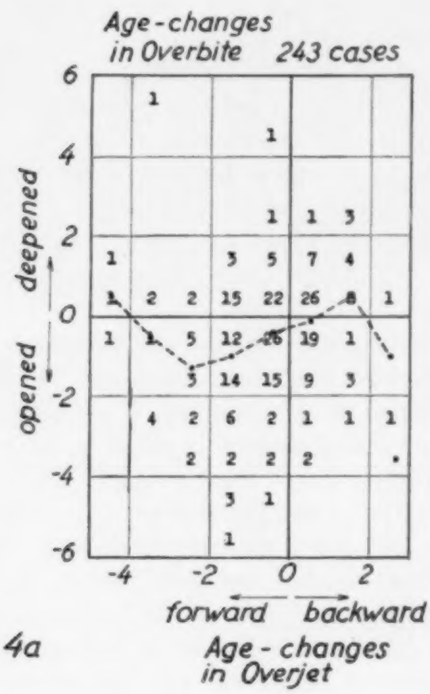


Fig. 4a

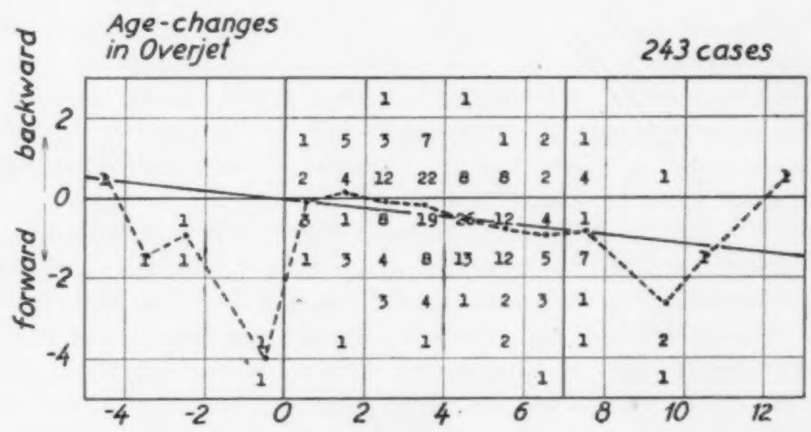


Fig 4 b

Fig. 4.—*a*, Diagram showing the distribution of the age changes in overjet and overbite. A reduced value of the determination for overjet with age indicates a more forward position of the lower incisors in relation to the upper incisors. The dashed line indicates the average age change in overbite for each millimeter's age change in overjet. *b*, Diagram illustrating the magnitude and direction of the age changes in overjet from 12 to 20 years in relation to varying degrees of overjet at 12 years. The straight line indicates the relation expressed in the form of a linear regression. The dashed line connects the mean values in each millimeter class for overjet at 12 years.

two occlusal groups. A further analysis has proved that the variability in facial growth occurs independent of the occlusal type, but this analysis is too extensive to be incorporated here.

These functional factors may be operative even under conditions of mandibular overjet, preventing it from keeping pace with the increase in mandibular protrusion relative to the upper jaw. However, the group of cases is numerically too small to give a clear picture of the variations in the development of cases with different degree of mandibular overjet. Nevertheless, the distribution indicated that the protrusion of the mandibular incisors with age in relation to those of the upper is not more pronounced than for the entire material.

With regard to the dispersion of the age changes in overjet we will find, as illustrated in Fig. 4, *b*, developmental changes in both directions. In the center group (b_1), in which molar occlusion is generally normal, changes may occur in the direction of mandibular as well as of extreme maxillary overjet. Similar age changes in both directions also occur in the two extreme groups.

In the group with extreme maxillary overjet, in which most Angle Class II cases are found, there are thus cases which show a tendency to an occlusal change in the direction of normal occlusion, others remain unchanged, while others again show a change in the direction of increased maxillary overjet.

In the group with mandibular overjet at the age of 12, we also find cases in which mandibular overjet increases, and others in which it remains unchanged. In this sample no case shows a diminishing mandibular overjet, although such cases are known to occur, as illustrated in Fig. 9, which represents an earlier developmental period.

The displacement of the sagittal occlusion in the lateral segment of the dental arches has not been calculated, but may be estimated to be within the limits ± ½ premolar or cuspal width. Examples of such occlusal changes from this sample are given in Figs. 7 and 8.

As the question of changes in the sagittal occlusion with advancing age is of great importance, both theoretically and clinically, the values of overjet at 12 and at 20 years for the same individuals are coordinated in a diagram (Fig. 5). The coefficient of correlation is 0.83 and significant. The dashed lines indicate the age changes to be expected within the limits plus or minus two standard deviations around the regression line, i.e., they correspond to 95 per cent of the dispersion with age. This diagram illustrates the same facts as those given in Fig. 4, *b*, and, as previously mentioned, shows a tendency toward a curved relationship.

Cases with normal values in overjet at 12 years thus generally show a lesser tendency to a decrease in the overjet value than cases belonging to the two extreme groups, and, therefore, also comprise cases with the greatest increase in overjet with age. This fact is very important from a clinical point of view.

Mandibular overjet or Class III cases with a change in the occlusion toward increased mesial occlusion with age, within the normal limits, is naturally more unfavorable from the point of view of bite development and orthodontic treatment than cases of distal occlusion, which show the same degree and direction

of a displacement toward normal occlusion. However, there is apparently no fundamental difference between these two phenomena, even though the former has been observed more.

It should be pointed out, however, that the limits between extreme cases in a normal distribution and in a pathologic development are indefinite. The number of cases of mandibular overjet showing extremely progressive development, i.e., greater than can be considered within normal limits, seem to be comparatively small in relation to the frequency of mandibular overjet cases. The prognosis of early orthodontic treatment of mandibular overjet, therefore, generally can be considered rather good.

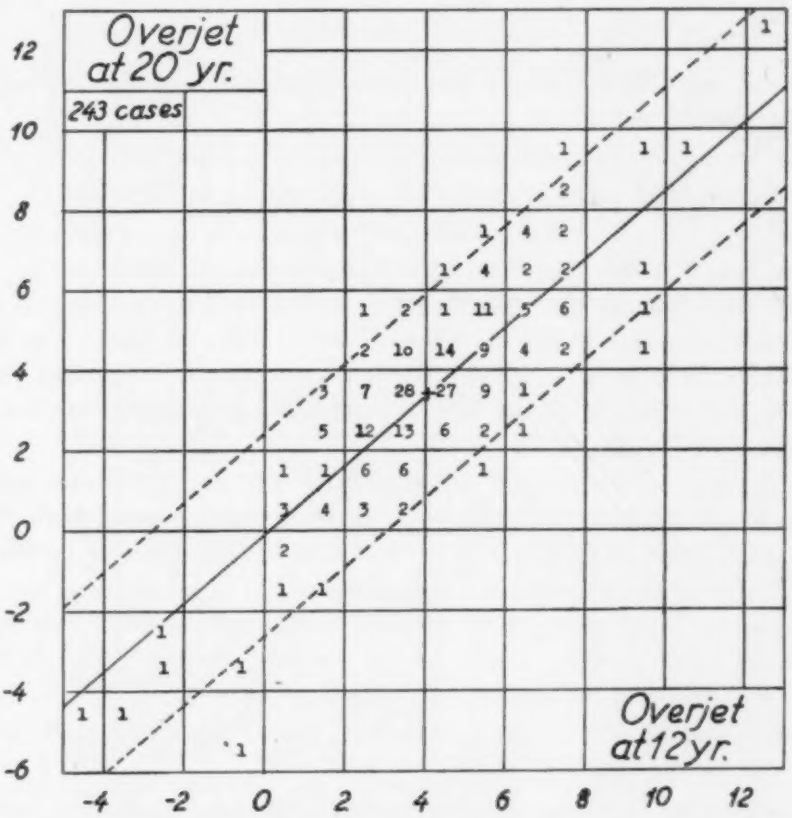


Fig. 5.—Diagram illustrating the values of overjet at 20 years at different degrees of overjet at 12 years. The dashed lines indicate the dispersion of the age changes in overjet around the regression line within the limits two times the standard deviation.

In cases in which the mandible continues its longitudinal growth after the development of the facial structure has otherwise ceased, a progenic hyperplastic mandible seems to develop, roughly regardless of the primary type of bite. Such a development from normal occlusion at the age of 20 to mesial occlusion at the age of 23 is illustrated in Fig. 10.

In cases of pathologic development of the face, e.g., in acromegaly with hyperplastic mandibular growth, or in cases of hypoplastic development of the mandible as in early lesions of the condyles, the picture is, of course, a different one.

The general trend of the development in the direction toward a relatively more forward position of the lower arch also manifests itself in the form of a change with age in the number of cases in the three groups of overjet, i.e., the center group and the two extreme groups.

This displacement of the frequency distribution from the age of 12 to 20 years in the same individuals appears from Table III, the grouping following that given in Table I and Fig. 2, *b*.

TABLE III

AGE (YEARS)	a_1	b_1	c_1
12	6 (2%)	216 (89%)	21 (9%)
20	10 (4%)	220 (91%)	13 (5%)

This change with age in the frequency distribution of the occlusal pattern is not pronounced, however.

As shown above the individual deviations are considerably greater than the average change, and differ individually with regard to direction.

In reality, there is thus a considerably greater change in the occlusion with advancing age than would appear from a comparison of the frequency distribution in the different age groups. In other words, it is not necessarily the same individuals who appear in the same bite group at different ages. The frequency calculation is, therefore, of a very limited value as an expression of the age changes in the structure of the bite, and should not be used for this purpose, as has been done previously.

The changes in the vertical occlusion with advancing age also may be discussed in greater detail. The range of variation for changes in overbite with advancing age from 12 to 20 years is illustrated by the diagram in Fig. 3. The great majority of cases show a change in the direction of reduced overbite. In many cases the depth of the bite remains unchanged, in others the bite opens in the course of the development. In other words, we find a similar dispersion for these changes with advancing age, as in cases of overjet.

Broadly speaking, however, primarily different types of bite show a certain dissimilarity in this respect.

If, as illustrated in Fig. 6, *a*, we correlate the age changes in overbite with the primary degree of depth of bite, i.e., with the type of bite found at the age of 12 years, we find a significant negative correlation (–0.31). This means that primarily deep-bite cases (c_2) show a greater tendency to open than normal overbite cases, while open-bites will show a tendency to close, a fact that is of clinical importance. The dispersion around the regression line is very great, however, which indicates great individual dissimilarity in development. The dispersion in the group of primarily open-bite (a_2 in Fig. 6, *a*) is significantly greater than in the other groups (b_2 and c_2).

The dispersion in overbite with age, which takes place in both directions, also is illustrated by the diagram in Fig. 6, *b*, in which the correlation is cal-

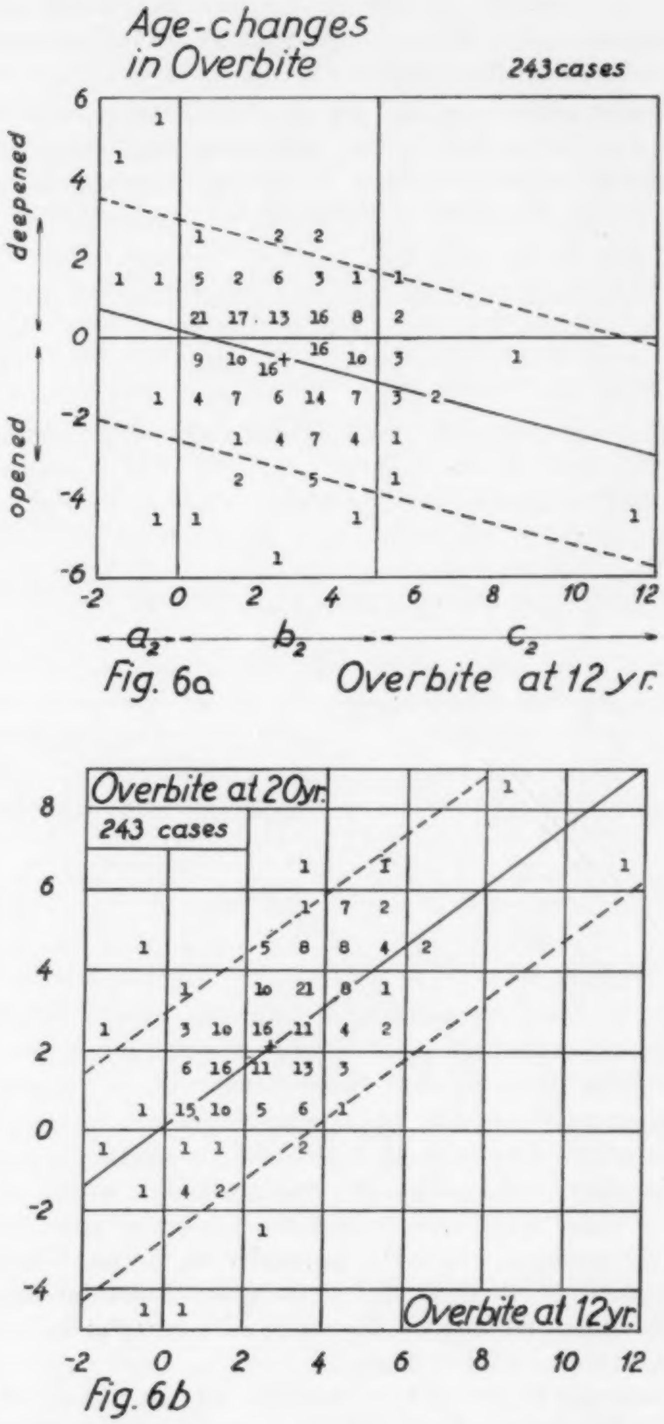


Fig. 6.—*a*, Diagram illustrating the magnitude and direction of the age changes in overbite from 12 to 20 years, in relation to varying degrees of overbite at 12 years. *b*, Diagram showing the values in overbite at 20 years at different degrees of overbite at 12 years.

culated between the values for overbite in the same individuals at 12 and at 20 years. The dispersion of the age changes (± 2 s) around the regression line is greater for overbite than for overjet (Fig. 5).

The general displacement in the degree of overbite toward bite opening in the course of the growth and development of the individual also appears from a smaller change in the frequency distribution between the center group and the extreme groups, according to Table IV.

TABLE IV

AGE (YEARS)	a_2	b_2	c_2
12	6 (2%)	222 (92%)	15 (6%)
20	15 (6%)	213 (88%)	15 (6%)

As has been shown previously, the values of both overjet and overbite generally decrease with age. However, there is an individual variation in both determinations, so that the age changes show a deviation in both directions.

A comparison of the frequency distribution of the various group combinations of overjet and overbite, arranged according to the combination method (Fig. 2, *b*), is given in Table V at the two age levels.

TABLE V

	a_1	b_1	c_1
12 YEARS			
c_2	2 (0.8%)	10 (4.2%)	3 (1.0%)
b_2	3 (1.0%)	202 (83.0%)	17 (7.0%)
a_2	1 (0.5%)	4 (2.0%)	1 (0.5%)
20 YEARS			
c_2	3 (1.0%)	8 (3.0%)	4 (2.0%)
b_2	6 (2.5%)	198 (81.0%)	9 (4.0%)
a_2	1 (0.5%)	14 (6.0%)	0

The number of cases representing the various group combinations does not differ notably with age; this is due to what was mentioned previously about the individually different direction of these changes.

The frequency distribution for these group combinations, therefore, is comparatively stable with advancing age. However, it should be borne in mind that it is not necessarily the same individuals who fall within the same bite groups at different age levels, even though the number of cases in each group remains relatively constant. It is the dispersion of the age changes which is the actual expression of the dynamics in the growth and development of the bite, and frequency calculations, which would give completely misleading figures, should not be used for that purpose.

The age changes in the occlusion described here during the developmental period from 12 to 20 years can be considered largely a secondary consequence of changes not only in the size but also in the shape of the various parts of the facial skeleton and the cranial base. In this way the sagittal jaw relation will change with age in one direction or the other, producing secondary changes

in the occlusion. Changes due to functional modeling also will occur, being of a compensatory or of a dysplastic nature, and thus greatly influencing the age changes in alveolar prognathy or the inclination of the incisors.

As shown in an article of 1951, the facial pattern changes markedly in the course of the period from 12 to 20 years of age.[4] Changes in the facial shape and in the occlusion apparently follow the same lines during early development (Fig. 9), although the magnitude of such age changes is not known.

Changes in the sagittal relation of the jaws are especially pronounced in the fetal stage and during the first few years of life. It is considered that during the latter half of the fetal stage the protrusion or prognathism of the mandible generally decreases up to the time of birth, then progressively increases during the first year of life. This sagittal displacement of the lower jaw in relation to the upper jaw has been associated in the orthodontic literature with a difference in the growth and development of the upper face and the mandible with regard to time. However, it seems very likely that this change in the prognathism of the lower jaw is also a consequence of the fetal change of shape of the cranial base. The latter shows a marked flattening from 4 up to 9 months of fetal age, and then again becomes more curved during the first few years of life.[13]

The shape of the cranial base, however, is not, as previously supposed, constant during the late period of development. In our series, the angle: nasion—the center of the sella turcica—basion has been calculated to be 130.8 ± 0.29 degrees at the age of 12 years, showing a slight increase of 0.72 ± 0.13 degrees up to the age of 20 years on an average. However, in this case, too, there are pronounced individual differences in the development, so that this angle in certain individuals shows a great increase, in others a great decrease, with a standard deviation of 1.9 degrees around the mean difference. The maximal increase has been measured to be 5.5 degrees, whereas the maximal decrease amounts to 4.5 degrees, i.e., the range of variation is 10 degrees.

The interrelation between the shape of the base of the skull and the degree of prognathism of the mandible can be estimated by a calculation of the correlation between the age changes of these two properties from 12 to 20 years.

The correlation coefficient for the age change in the shape of the cranial base, measured from the angle: nasion—the center of the sella turcica—articulare, and the age change in the mandible's prognathism, expressed as the angle: sella turcica—nasion—pogonion, is negative and significant (–0.31). In other words, the mandible's prognathism increases when the cranial base becomes increasingly curved with advancing age, and decreases when the cranial base becomes flattened. The correlation coefficient is the same if the shape of the cranial base is expressed by the angle: nasion—sella turcica—basion (–0.33).

The relationship between the change in shape of the cranial base and the changes in the mandible's prognathism is further significant when the partial correlation coefficient for these properties is calculated, maintaining the age changes in the inclination of the mandible in relation to the cranial base constant (–0.74).

A.

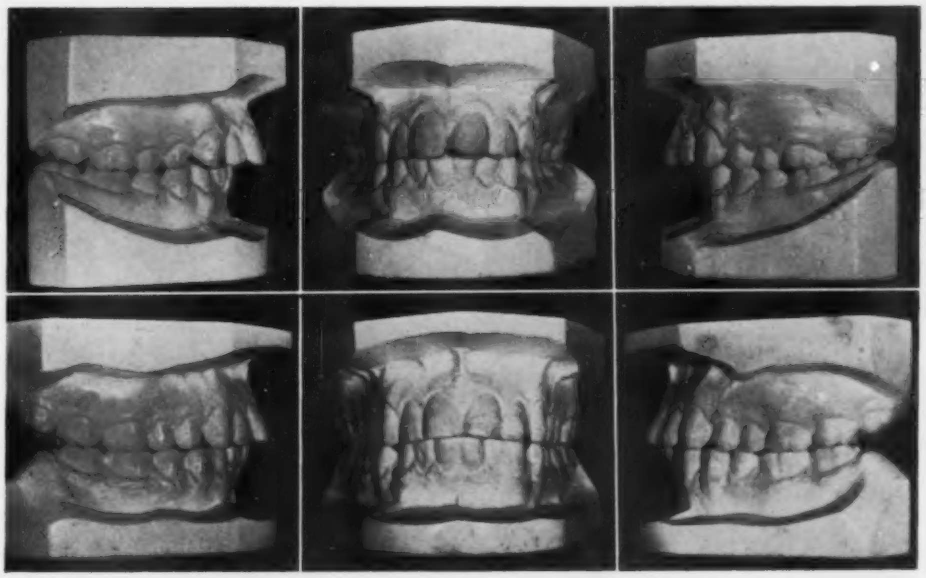
B.

Fig. 7.—*A*, *B*, and *C*, X-ray pictures of three individuals studied, illustrating different patterns of occlusal changes from 12 to 20 years. The changes in overjet are −3, +2.6, and −3 mm., respectively. *A* (Case V 119) shows a change with age from normal to ½ mesial occlusion; *B* (Case V 254) shows a change from normal to ½ distal molar occlusion; *C* (Case V 312) illustrates a change from ½ distal to normal occlusion.

Fig. 7C.

Fig. 7C. (For legend, see opposite page.)

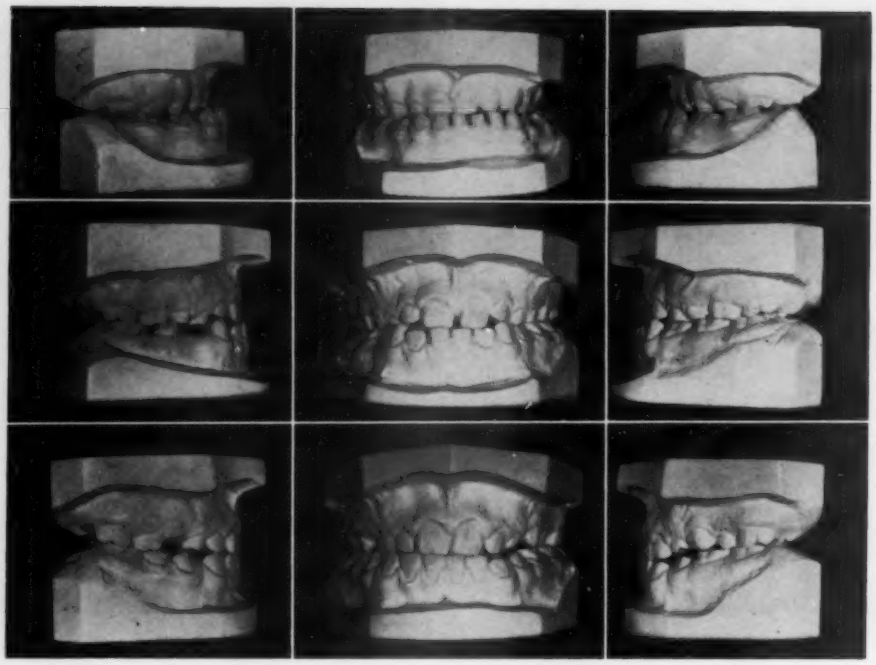
A.



B.

Fig. 8.—Photographs of dental casts (Case V 312) showing a change from distal to approximately normal occlusion from the age of 12 years (A) to the age of 20 (B).

A.

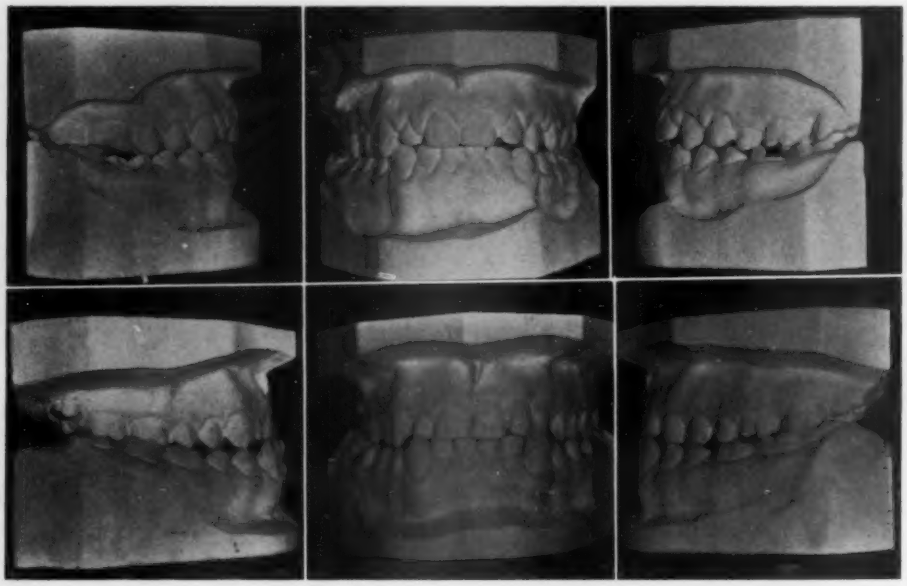


B.

C.

Fig. 9.—Photographs of a case (C 324♀) showing a gradual occlusal change from mesial to nearly normal occlusion during the earlier developmental period. *A*, Shows the condition at the age of 3 years, *B*, at the age of 8, and *C*, at the age of 10 years.

A.



B.

Fig. 10.—Photographs of a case (C 1♂) illustrating a change from normal to mesial occlusion from the age of 20 (*A*) to the age of 23 years (*B*).

Age changes in maxillary prognathy, expressed by the angle sella turcica —nasion—subspinale (the point A according to Downs[8]) also are related to some extent to the change in shape of the cranial base with advancing age ($r = -0.33$). The change in shape of the cranial base, however, is only one of the factors influencing the age development of the prognathism.[3, 4]

As pointed out in our previous investigations of 1947, it is also the difference in the development of the maxillary and mandibular prognathism which is the decisive factor in the sagittal occlusion, and not the degree of prognathism in itself. Therefore, the age change in overjet is to a lesser degree dependent upon the age change in the mandibular prognathism ($r = 0.16$), or upon the age change in the maxillary prognathism ($r = 0.05$), but is the more dependent upon a different prognathous development with regard to size and direction of both jaws. If we now correlate the age change in overjet with the age change for the difference in prognathism between the two jaws, we find that the correlation coefficient is considerably greater ($r = 0.25$). However, this problem will be dealt with in greater detail in subsequent articles.

The great age changes in the occlusion of the dental arches described here may be regarded as the combined effect of developmental changes within the dental arches, as well as in the facial structure as a whole. Functional conditions, such as lip and tongue pressure, thereby seem to play a very important role as modifying factors in the bite development.

SUMMARY

A bite analysis in growing individuals should comprise an estimate of the change in the occlusion which may be expected up to adult stage. A necessary condition hereof is that changes in the bite are known with regard to size and direction for various stages of the development.

The present article is confined to an analysis of variability and age changes in sagittal and vertical occlusion during the late developmental period. The age changes in the sagittal and vertical incisal occlusion have been calculated statistically with regard to size and direction in a group of 243 Swedish boys by an examination at the age of 12 and a re-examination at 20 years. The following findings of special importance may be mentioned:

1. The variability in overjet is greater than in overbite, at the ages of both 12 and 20 years.

2. The age changes for both overjet and overbite show pronounced individual difference, with regard to both direction and size. The age changes are greater for overbite than for overjet.

3. The overjet generally changes with advancing age, so that the front teeth of the lower arch show a forward displacement in relation to those of the upper one. These general age changes are comparatively slight. The individual differences, expressed as the dispersion of the age changes, are very great, however. In some individuals the relative forward displacement of the front teeth of the lower jaw is very pronounced, the maximum being 4.8 mm. in the present series of cases. A relative backward displacement of the lower dental arch takes place in other individuals, the maximum is 2.6 mm. in this series.

The range of variation for these age changes in the overjet (7.4 mm.) is the best expression for the dynamics in the development of the bite. The calculated standard deviation for these age changes is 1.2 mm.

The age change in the sagittal molar occlusion is estimated to be within the limits ± ½ cuspal width, with a certain general tendency to a relative forward displacement of the lower arch and with great individual differences.

4. Generally the overbite decreases somewhat with advancing age. Individually, the standard deviation of the age changes also is very great, and different with regard to direction. The range of variation is 10.1 mm. with a standard deviation of 1.4 mm. In the present series the largest opening of the bite with advancing age is 5.1 mm., and the largest deepening of the bite is 5 mm.

5. In two out of three children the change in overjet or overbite exceeds ± 1 mm. from 12 to 20 years.

6. The general tendency with age to a forward displacement of the lower incisors in relation to the upper incisors differs as to magnitude in primarily different types of sagittal occlusion. This forward displacement of the lower arch with age in relation to the upper arch is on an average greater in mandibular as well as in extreme maxillary overjet cases than in cases with normal value of overjet. This indicates a relationship of nonlinear type and is explained as an effect of functional modeling during the bite development.

7. Age changes in the overbite also show a certain relationship with the primary type of bite. Deep-bites show a greater tendency to open than normal overbites, whereas open-bites show a tendency to close. Individual differences, however, are pronounced.

8. A calculation of the frequency of different types of malocclusion at different age levels cannot be used to express changes in the occlusion with advancing age. Differences in frequency at different age levels will be indicative only of the general growth tendencies. These are slight in relation to the standard deviation of the growth changes. It is the standard deviation of the age changes which is the actual expression of the dynamics in the growth and development of the bite. This tends in both directions, so that the frequency values become relatively stable with advancing age.

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THE ROYAL DENTAL COLLEGE, UNIVERSITETSPARKEN, 4.

Department of Orthodontic Abstracts and Reviews

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Abstracts Presented Before the Research Section of the American Association of Orthodontists, April, 1952

A Serial Radiographic Study of Velopharyngeal Closure and Tongue Position in Certain Vowel Sounds: By R. L. Williams, D.D.S., M.S.D., Northwestern University Dental School, Department of Orthodontics, Chicago, Ill.

The subjects used for this study were thirty graduate and undergraduate students of the Northwestern University Dental School. All were men, ranging in age from 22 to 35.

The method used in this study was radiographic, utilizing the Broadbent-Bolton cephalometer to position the subject's head. In order to study the tongue and the nasopharynx radiographically, it was considered necessary to place radiopaque markers upon the superior surface of the soft palate, the posterior wall of the pharynx at the position of the velopharyngeal closure, and upon the tongue. As a marker for the tongue, a fine brass link chain 0.017 inch in diameter of the type used to activate the dial of a barometer was used.

The vowel sounds studied were: *a* as in spa, *a* or *æ* as in pap, *u* as in toot, and *i* as in peep.

SUMMARY

1. Satisfactory radiographs of the structures associated with velopharyngeal closure may be made with the technique described in Chapter III.

2. It is feasible that these radiographs could be used clinically for proper positioning of the speech bulb.

3. The hypothesis that the nasopharyngeal valve is closed for all vowel sounds is not borne out by this research.

4. There is a similarity in the amount of opening of the nasopharyngeal valve between the sounds *u* and *i*; and between the sounds *a* as in pap and *a* as in spa. The valve is predominantly open for the latter sounds and closed for the former.

5. There was no significant difference found between the position of the posterior pharyngeal wall at rest and in function. This suggests the possibility that Passavant's ridge does not function in the sounds studied.

6. When the valve was closed, the contour of the posterior pharyngeal wall presented a gentle convexity. In only one case was the typical Passavant's ridge visible.

7. A high degree of correlation was found to exist between the vertical positions of the soft palate and the back of the tongue in the sounds studied.

A Radiographic Study of the Positions of the Mandibular Condyle at Physiologic Rest Position and at Occlusion of the Teeth in Individuals Possessing Cleft Palate Deformity: By A. P. Arnstine, D.D.S., M.S.D., Northwestern University, Chicago, Ill.

The subjects used for this study were thirty children who were between the ages of 7 and 16. These children were selected because they possessed similar cleft palate deformities and all had undergone surgical correction of the cleft within the same period of chronological age. Specifically, they all possessed cleft palate deformity of both the hard and the soft palate and all had been surgically treated for the cleft at least once before reaching 3 years of age.

These patients underwent radiographic investigation which included the taking of oriented lateral head radiographs using the Broadbent-Bolton cephalometer and also the taking of four temporomandibular radiographs using the Donovan orienting accessory device.

SUMMARY

1. Analysis of cases of cleft palate individuals must include radiographic records made when the mandible is at rest position and also when the teeth are in occlusion. Patients may appear to have good facial patterns at rest position, but, due to maxillary growth deficiency, may appear to have gross facial deformities with the mandible in its occlusal position.

2. In two-thirds of the patients, when the mandible was at rest position the anterosuperior surface of the condyle was in close relation to the postero-inferior surface of the articular eminence.

3. When the mandible was closed from rest position to occlusal position, 80 per cent of the cases showed a movement of the condyle in a posterior direction; that is, the condylar head was further into the depth of the mandibular fossa.

4. The direction of condylar movement in the mandibular closing movement was found to vary greatly. Superior, inferior, and posterior (and vector combinations) of these movements were exhibited. Fifty per cent of the cases displayed more than one and one-half millimeters of movement.

News and Notes

American Association of Orthodontists

The following is a list of local committees for the next annual meeting of the American Association of Orthodontists, which will be held in Chicago May 16 through May 20, 1954.

LOCAL ARRANGEMENTS

G. Hewett Williams, Chairman, 4753 Broadway, Chicago 40, Ill.
Ralph G. Bengston, Treasurer, 25 E. Washington St., Chicago 2, Ill.
Sidney Asher, 4753 Broadway, Chicago 40, Ill.
B. F. Dewel, 708 Church St., Evanston, Ill.
Abraham Goldstein, 109 N. Wabash Ave., Chicago 2, Ill.
Leonard Grimson, 636 Church St., Evanston, Ill.
William A. Murray, 636 Church St., Evanston, Ill.
Harland L. New, 309 Touhy Ave., Park Ridge, Ill.
Richard A. Smith, 636 Church St., Evanston, Ill.
Howard E. Strange, 2376 E. 71st St., Chicago 49, Ill.

REGISTRATION

Franklin A. Squires, Cochairman, Medical Centre, White Plains, N. Y.
Leonard Grimson, Cochairman, 636 Church St., Evanston, Ill.
J. P. Baldridge, 32 S. River St., Aurora, Ill.
Vernon R. Boman, 7 W. Campbell St., Arlington Heights, Ill.
Wm. S. Bradford, 2 N. Sheridan Rd., Highland Park, Ill.
Milton B. Engel, 55 E. Washington St., Chicago 2, Ill.

RECEPTION

James A. Burrill, Chairman, 812 Greenwood Ave., Wilmette, Ill.
Charles R. Baker, 636 Church St., Evanston, Ill.
Frederick B. Noyes, 621 Park Place, Park Ridge, Ill.
Lloyd S. Lourie, 333 Fifteenth St., Santa Monica, Calif.

BANQUET AND LUNCHEONS

Richard A. Smith, Chairman, 636 Church St., Evanston, Ill.
Russell K. Ephland, 3 S. Prospect Ave., Park Ridge, Ill.
William F. Ford, 55 E. Washington St., Chicago 2, Ill.

LADIES' ENTERTAINMENT

Harland L. New, Chairman, 309 Touhy Ave., Park Ridge, Ill.
Ione J. K. Kral, 501 Franklin Ave., River Forest, Ill.
A. Florence Lilley, 55 E. Washington St., Chicago 2, Ill.
Beulah G. Nelson, 715 Lake St., Oak Park, Ill.

SUNDAY NIGHT BUFFET

Abraham Goldstein, Chairman, 109 N. Wabash Ave., Chicago 2, Ill.
Frederick T. Barich, 636 Church St., Evanston, Ill.

T. M. Graber, 670 N. Michigan Ave., Chicago, Ill.
F. J. Krivanek, 212 S. Marion St., Oak Park, Ill.
Harry J. Kent, 4803 Lincoln Ave., Chicago 25, Ill.
Asa J. LaGrow, 715 Lake St., Oak Park, Ill.
Paul Wilcox, 603 Main St., Evanston, Ill.

STAG DINNER

William A. Murray, Chairman, 636 Church St., Evanston, Ill.
Howard J. Buchner, 1011 Lake St., Oak Park, Ill.
Ralph A. L. Logan, 2 N. Sheridan Rd., Highland Park, Ill.

CLINICS

Howard E. Strange, Chairman, 2376 E. 71st St., Chicago 49, Ill.
Arthur B. Block, 2376 E. 71st St., Chicago 49, Ill.
G. L. Christopher, 1525 E. 53rd St., Chicago 15, Ill.
Francis J. Hanagan, 1791 Howard St., Chicago 26, Ill.
John C. McGuire, Jr., 636 Church St., Evanston, Ill.
Harold Schwartz, 55 E. Washington St., Chicago 2, Ill.
Karl von der Heydt, 715 Lake St., Oak Park, Ill.
Robert L. Williams, 4753 Broadway, Chicago 40, Ill.

COMMERCIAL EXHIBITS

Sidney Asher, Chairman, 4753 Broadway, Chicago 40, Ill.

PRESS

B. F. Dewel, Chairman, 708 Church St., Evanston, Ill.
H. C. Pollock, 8015 Maryland Ave., St. Louis, Mo.
Earl E. Shepard, 4500 Olive St., St. Louis, Mo.

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William A. Murray, Chairman, 636 Church St., Evanston, Ill.
Charles R. Baker, 636 Church St., Evanston, Ill.
Allan G. Brodie, 30 N. Michigan Ave., Chicago 2, Ill.
James A. Burrill, 812 Greenwood Ave., Wilmette, Ill.
John R. Thompson, 55 E. Washington St., Chicago 2, Ill.

Central Section of the American Association of Orthodontists

The Central Section of the American Association of Orthodontists will hold its sixteenth annual meeting in Chicago, Ill., Oct. 19 and 20, 1953, at which time the following program will be presented.

SCIENTIFIC PROGRAM

MONDAY, OCT. 19, 1953

*Morning Session**

8:00 Registration and banquet tickets
9:00 Invocation
9:05 Address of Welcome
Response
9:15 President's Address
9:30 A Critical Review of Cephalometrics. Dr. Alexander Sved, New York, N. Y.

*The program for the morning session on October 19 will be given and arranged by the Chicago Association of Orthodontists, Dr. Fred Barich, President, and Dr. William Ford, Chairman of the Program Committee.

10:30 Case Reports—Demonstrating: (1) A Successful Result; and (2) An Unsuccessful Result. Dr. John R. Thompson, Chicago, Ill.
11:30 Business Meeting
12:30 Luncheon

Afternoon Session

2:00 Clinical Application of Recent Diagnostic Research in the Treatment of Dento-Facial Anomalies. Dr. Robert W. Donovan, Chicago, Ill.
3:00 The Problem of Growth and Development as It May Affect the Limitations of Orthodontics. Dr. Wilton Marion Krogman, Philadelphia, Pa.

TUESDAY, OCT. 20, 1953

Morning Session

9:00 Treatment Forum—Dr. T. M. Graber, Moderator.
Participants:

Dr. Howard E. Strange, Chicago, Ill.
Dr. Beulah Nelson, Oak Park, Ill.
Dr. Silas J. Kloehn, Appeton, Wis.
Dr. Earl E. Shepard, St. Louis, Mo.

11:00 A Cephalometric Serial Case Report Involving the Oliver Guide Plane
11:30 The American Board of Orthodontics
Dr. C. Edward Martinek, Secretary, American Board of Orthodontics, Detroit, Mich.

Afternoon Session

CLINIC PROGRAM

Title:

1. Modified Hawleys. Maynard E. Cook, Austin, Minn.
2. Malocclusion Treated With Extra Oral Anchorage. Beulah G. Nelson, Oak Park, Ill.
3. The Face Bow and Cervical Gear in Action. Sidney Asher, Chicago, Ill.
4. Construction of Loop Molar Bands From Stainless Steel. Russell K. Ephland, Park Ridge, Ill.
5. Attempts to Cope With Some of the Habits Which Seem to Interfere With the Development of Normal Occlusion. David J. Thompson, Elmhurst, Ill.
6. Cold Cure Acrylic Retainers. Max R. Kadesky, Dubuque, Iowa
7. A Series of Case Reports Photographically Recorded and Some Helpful Suggestions. Leonard P. Wohl, Wausau, Wis.
8. Cephalometric Appraisal of Headcap Treatment. Donald Ketterhagen, Milwaukee, Wis.
9. A Simplified Photographic Procedure. L. T. Oldham, Mason City, Iowa
10. The Dominance of the Morphologic Pattern. Abraham Goldstein, Chicago, Ill.
11. Reduction of Forces Used in Class II Treatment by Edgewise Application to Lower. Howard N. Delbridge, Beloit, Wis.
12. A Punch Card File for Patient Records. Karl vonderHeyt, Oak Park, Ill.
13. Diagnosis in Mixed Dentition. Cases With the Idea of Adjusting Tooth Mass to Basal Bones. Ben L. Herzberg, Chicago, Ill.
14. Uses of Hawley Type Acrylic Retainer as an Anchorage Device. W. R. Sanders, Biloxi, Miss.
15. Demonstration of Mass Distal Tipping Bends. Earl W. Renfroe, Chicago, Ill.
16. Unretained Orthodontic Corrections. George L. Englert, Danville, Ill.
17. (a) Unsoldered Spring Force to Open Spaces. (b) Use of Hawley Arch Forms as Guides in Determining Desired Tooth Positions. W. E. Stoft, Omaha, Neb.

Great Lakes Society of Orthodontists

The following program will be presented at the twenty-fourth annual meeting of the Great Lakes Society of Orthodontists which will be held Nov. 2, 3, and 4, 1953, at the Pantlind Hotel, Grand Rapids, Mich.

MONDAY, NOV. 2, 1953

Morning Session

Commercial exhibits open.
First business session.
Dr. T. Speidel: A Survey of Orthodontic Limitations.

Afternoon Session

Dr. J. Harvold: Cleft Palate Morphology and Therapy.
Dr. R. Coleman: The Supervision Period.

TUESDAY, NOV. 3, 1953

Morning Session

Mr. Jules King: Economics.

Afternoon Session

Dr. W. M. Krogman: Statics and Dynamics of Growth.
Dr. Bercu Fischer: The Need for a Three-Dimensional System for Orthodontic Diagnosis and Treatment.

Evening Session

President's reception and banquet.

WEDNESDAY, NOV. 4, 1953

Morning Session

Dr. J. Jarabak: Effects of Condylar Resection on Growth of Cranial and Facial Components of the White Rat.
Dr. R. Moyers: Limitations Associated With Muscles and Temporomandibular Articulation.
Closing business session.

Middle Atlantic Society of Orthodontists

The next meeting of the Middle Atlantic Society of Orthodontists will be held at the Claridge Hotel in Atlantic City, N. J., Sunday, Monday, and Tuesday, Oct. 18, 19, and 20, 1953.

Denver Summer Meeting for the Advancement of Orthodontic Practice and Research, Inc.

The following is from a eulogy read before the Denver Seminar in August, 1953, by J. W. Norris, D.D.S.

A EULOGY TO DR. ELMER S. LINDERHOLM

To a man we all knew and loved as "Lindy," this, another wonderful seminar, is dedicated. This is fitting, indeed, for he was, and is today, a very definite part of it. His reverent belief in his profession was amply demonstrated by the manner in which he carried out his duties and obligations as an officer of this seminar. Uncomplainingly, he gave of his time and strength to a cause which he believed in dearly. He was always an inspiration to the younger men, this being one of the basic fundamentals upon which this seminar was founded. His winning smile and pleasant disposition, his enthusiasm for the good in everything, his striving for further knowledge, and his eagerness to help someone less fortunate or less capable

than himself (even though he had not been in the best of health for several years) won for him many friends throughout this country. He commanded respect from anyone acquainted with him. He was devoted to his family, consisting of his wife and one son, but he also could easily be one of the boys—a man's man. He was a great lover of horses and the great outdoors, and riding, golfing, fishing, hunting, raising fine cattle, and farming were among his many forms of recreation. All these attributes can be summed up in five short words: "He was a great guy."

I had the pleasure of serving under Dr. Linderholm in World War II, and in the early stages of the war I saw him burdened with the tremendous responsibilities of handling men who were trying to adjust themselves to a new way of life, inspiring them to do the best dentistry possible with very meager equipment, consoling some, and encouraging others. Through all this he never once let himself forget that he was their example. He was a true leader.

The spirit of Dr. Linderholm remains with us today. There have been others like him from this group who have gone on before, and many more will follow. It takes all of these men to make our seminar really great.

The Denver Summer Meeting for the Advancement of Orthodontic Practice and Research, Inc. held its sixteenth annual meeting at the Park Lane Hotel, Denver, Colo., Aug. 2 through 7, 1953.

The 1953 meeting was dedicated to the fond memory of: Dr. Elmer S. Linderholm, Denver, Colo. (Secretary 1949 to 1952), and Dr. Charles M. Waldo, Boston, Mass. (Co-founder and charter member).

Discussion leaders and program follow:

WILTON MARION KROGMAN, Ph.D.

PHILADELPHIA, PA.

General Theme: PUTTING GROWTH TO WORK IN PRACTICE.

Factors Influencing Growth—Heredity.
Factors Influencing Growth—Endocrines.
The Use and Interpretation of Height-Weight Data, with Special Reference to the Wetzel Grid.
The Growth of the "Whole Child"—A Useful Concept in Operation.
An Analytic Interpretation of Orthodontic Case Histories From the Standpoint of Growth Status and Progress.

DONALD C. MACEWAN, D.D.S.

SEATTLE, WASHINGTON

Topics of Discussion:

Treatment Objectives
Anchorage
Treatment Planning
Appliance Therapy
Tricks with Wire

H. C. POLLOCK, D.D.S.

ST. LOUIS, MISSOURI

Topics of Discussion:

Orthodontic Trends, Past and Present
Pollock Fixed Removable Appliance

ALLEN S. RICHARDSON

DENVER, COLORADO

Topic of Discussion:

No Man Need Die Poor In a Capitalistic Economy

GADGET CLINIC

PANEL DISCUSSION

Moderator: George H. Siersma
Members of the Panel:
Wilton Marion Krogman
Donald C. MacEwan
William Roy Humphrey

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Curtis E. Burson, Asst. Secretary

†Deceased.

Australian Society of Orthodontists

The General Meeting of the Australian Society of Orthodontists was held June 4, 1953, during the Thirteenth Australian Dental Congress in Brisbane.

Officers elected at that time were:

President—Arthur Thornton Taylor, 175 Macquarie St., Sydney.

Hon. Secretary—Robert Y. Norton, St. James Bldg., 109 Elizabeth St., Sydney.

Hon. Treasurer—Robert W. Halliday, 131 Macquarie St., Sydney.

Committee:

K. T. Adamson, 111 Collins St., Melbourne.
D. F. Spring, 145 Collins St., Melbourne.
V. P. Webb, A.M.P. Bldg., Edward St., Brisbane.

University of Tennessee

The University of Tennessee College of Dentistry will offer a course in orthodontics leading to a Master of Science degree, beginning Jan. 1, 1954. Further information may be obtained from Dr. James T. Ginn, Dean of the College of Dentistry, 847 Monroe, Memphis 3, Tenn.

Notes of Interest

George M. Anderson, D.D.S., announces the removal of his office to The Northway, 3700 N. Charles St., Baltimore 18, Md., practice limited to orthodontics.

Dr. Allan G. Brodie desires to announce that his son, Dr. Allan G. Brodie, Jr., having completed his graduate training in orthodontics, is now associated with him in practice at 30 N. Michigan Ave., Chicago, Ill.

Dr. William J. Conley announces the opening of an office for the exclusive practice of orthodontics at 6907 Fifth St., N.W., Washington, D. C., and is continuing the practice of the late Dr. E. J. Copping.

Ulysses Erdreich, D.D.S., and Arnold Geiger, D.D.S., announce their association in the practice of orthodontics at 70 Market St., Poughkeepsie, N. Y., and 288 Wall St., Kingston, N. Y.

Hammond L. Johnston, D.D.S., announces the removal of his office to The Northway, 3700 N. Charles St., Baltimore 18, Md., practice limited to orthodontics.

Dr. Richard A. Lowy of Chatham, N. J., is continuing his branch office at the Carmen Apartments in San Juan, Puerto Rico.

Dr. Louis S. Winston announces the opening of his new office, Suite 1019-20 South Texas Bldg., San Antonio, Texas, practice limited to orthodontics.

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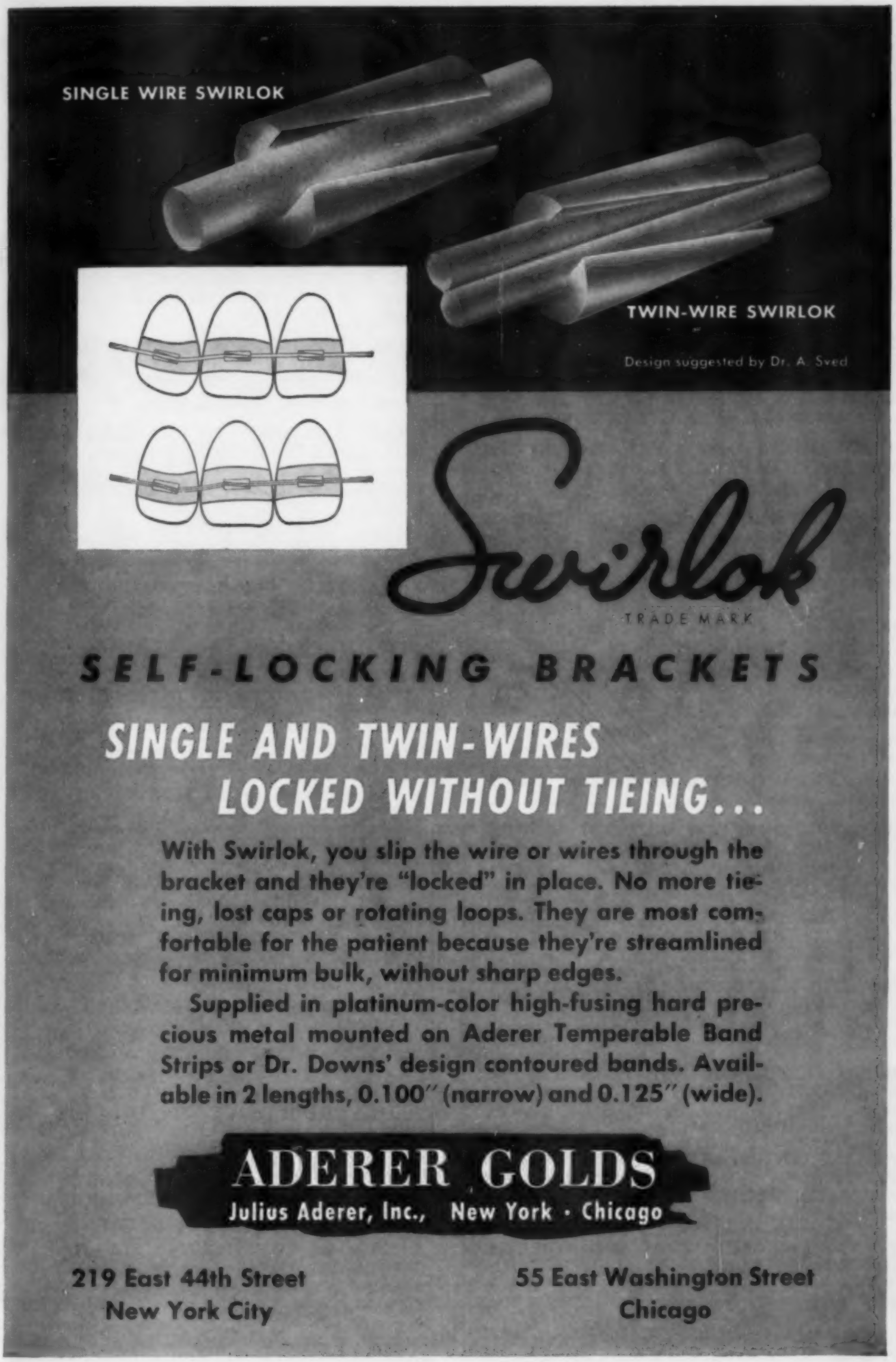
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